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SVIC NOTES

President Reagan has given new emphasis to the need for a strong national defense capability. It is clear that there will be a number of new thrusts – and increased effort on existing programs – related to aircraft, missiles, ground combat systems, ships and submarines. It seems likely that there will be increases in space programs, particularly those that may be defense-oriented. New and complex systems create new problems that must be solved. Many of these problems will relate to dynamic design; and, over the next few years, the ability of dynamicists will be severely tested. I think our technical community will meet the challenge and I look forward to reporting the new developments in dynamics that are sure to come.

With the new stress on defense, I am expecting that the 52nd Shock and Vibration Symposium will be a particularly rewarding meeting. The dates are 27-29 October 1981. The place is New Orleans. Appropriately, our host is the Defense Nuclear Agency and we will give special emphasis to topics in DNA's field of interest. As with all of our symposia, other timely topics will not be neglected. For example, tentative plans are already being made for a special session on Space Shuttle dynamics.

A preliminary announcement of the 52nd Symposium will be distributed by the time this issue goes to press. This year the announcement will call for suggestions for symposium topics and for potential authors to notify us of their intent to submit papers. In this way we hope to have prospective participants contribute to technical program planning. If you have not yet received an announcement, write to us and ask for one. By doing so you will also be sure to receive the final "Call for Papers" which will be issued in May.

In a previous issue of the DIGEST (October 1980) I promised to begin a series describing the capabilities of other information analysis centers. The purpose is to provide our readers with a guide to sources of information in related technologies. If all goes well, we will begin this new series in the May issue.

H.C.P.

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EDITORS RATTLE SPACE

COMPUTER USE FOR DATA ANALYSIS AND REDUCTION

Recently this column has contained some thoughts on the development and implementation of digital computers and their relation to the vibration field. Until recent years the digital computer was used sparingly for data analysis and reduction. The reasons included the difficulty of analog to digital conversion, lack of accessibility of large mainframe computers, and lack of user familiarity with computer capabilities. The appearance of minicomputers and fast Fourier transform (FFT) analyzers – a specialized form of the minicomputer – brought computer capability to the experimentalist and made the problem of data handling practical and manageable for small quantities of data.

The development of a practical algorithm for computation with the FFT analyzer allowed more powerful data analysis than had been available with filter type analyzers. The evolution of the FFT analyzer is also closely related to the new microprocessor technology. The power of the specialized analyzer provides capability not only for frequency analysis but also for time domain processing – averaging, analysis, and filtering. The more sophisticated versions of this instrument can be used to obtain coherence, transfer functions, power spectra, and other functions arising from digital signal processing. Many minicomputers now on the market are capable of performing similar analyses although the software is not widely available to date.

Today's minicomputer is a powerful tool for the engineering analyst. It has the capability not only for data analysis and reduction but also for mathematically based simulation of systems. The minicomputer can be used to compute system characteristics using mathematical analysis and trending of data. Extrapolation of data from a measurement point to an unmeasurable point at which data are required is also possible; such data are often necessary, and extrapolation can be made accurately and efficiently using digital simulation techniques. This capability also provides a power tool for diagnostic and correction type work because the simulations can be used to determine the effect of parameter changes on vibration response or stability.

Computer hardware and computational techniques are currently available to perform the analyses described above; however, much of the software necessary to implement these techniques is not yet generally available. Similarly, much of the system data required for simulation is available but needs to be developed. There is no doubt, however, that these powerful tools and the necessity to use them will stimulate rapid development of the software and data.

R.L.E.

VIBRATION OF CURVED BEAMS

Š. Markuš and T. Nánási*

Abstract. ***Because they are important in many practical applications, free vibrations of curved beams in their own plane or out-of-plane have been the subject of numerous investigations. This paper reviews various methods for analyzing the effects of curvature in connection with other complicating phenomena. These phenomena include rotatory inertia, shear deformation, extension of the central line, dislocations of the central and neutral axes, distribution of the stress along the cross section, damping, and boundary conditions. The influence of these phenomena on the mechanics of vibration of curved beams is also considered.***

The Rayleigh-Ritz method has been used to obtain the natural frequencies of inextensional [1-3] and extensional [4, 5] in-plane vibrations of rings, ring segments [6-9], non-circular arches having various boundary conditions [10-13], and arches of variable stiffness [14]. The Rayleigh-Ritz method has been used in conjunction with Lagrangian multipliers to find the natural frequencies of a simply supported arc vibrating in its own plane [15] as well as out-of-plane vibrations of a two-span curved beam on non-yielding supports [16]. Out-of-plane vibrations of circular arcs [17-19], non-circular arcs [20, 21], and horizontally curved beams used in bridge construction [22] have been analyzed using the same method.

ANALYTICAL METHODS

Classical analysis of spatially curved rods was carried out by Clebsch; his set of equilibrium equations has been published [4]. Love [4] developed the elementary theory for Euler-Bernoulli beams, in which bending-extensional coupling was neglected. Studies have been reported of inextensional vibrations of circular rings [6, 23, 24], elliptical rings [25], helical rods [4, 26-30], ring segments [6, 31-33], and frames composed of straight and curved members [34]. Damped vibrations of clamped-clamped rings or rings clamped at one end and having a prescribed time dependence displacement at the other have also been studied [35]. Wasserman [36] derived the differential equations governing inextensional bending vibration of arches in three cases of load behavior during the deformation process; he discussed [36-41] the natural frequencies and critical loads of arches with flexible ends.

The first detailed article dealing with the exact solution of free vibrations of curved beams was published by Waltking [42]. He showed that the natural frequencies of symmetric modes associated with in-plane bending are strongly influenced by bending-extensional coupling, especially in the case of slightly curved beams. His work initiated extensive studies of the effects of bending-extensional coupling and initial curvature. Beams with constant curvature [43, 44] have been studied, and simplified approaches for beams and clamped ring segments [45-46] have been developed. Initially extensioned rings [47] and extensional and inextensional behavior of beams and rings have been investigated [43, 48, 49]. Suitable models for the analysis of the vibrations of rings [50, 51] and curved beams [52] have been widely studied.

Timoshenko beams have been treated [53-69]. The first author to consider higher effects was Ḟederhofer [53, 54], but his solution, which contains a set of Bessel functions, is awkward and difficult to apply to complicated engineering problems. Perhaps the most widely used equations are those of Morley [55]. His equations were used to analyze secondary effects in arches with various shapes of the central line [56] and of varying cross sections [57] and to analyze viscoelastic beams [58]. An energy approach has been used to assume nonlinear variation of normal

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strains through the cross section [59]. In some cases only rotatory inertia was considered [60].

The dynamic response of a ring subjected to a distributed impulsive load has been examined [62, 63]; the shear coefficient was discussed. A simple expression for the in-plane vibration of a thick ring has been derived [64], and the analysis of a ring with constant cross section has been reported [65, 66]. The combined effects of initial curvature, transverse shear, and different boundary conditions upon the natural frequencies and mode shapes of transversely isotropic beams have been studied [67, 68], as has the damped case [69].

Free out-of-plane vibrations of curved bars have been treated [70, 71]. Equations of motion were solved for various shapes of the central line for beams with built-in, rolled, and simply supported ends. Upper and lower bounds to eigenfrequencies of bars have been obtained using the Lehman-Maehly method [72, 73]. Natural frequencies of incomplete rings with fixed ends [74] and of an intermediately supported U-bent tube [75] were calculated using classical equations given by Love. Forced [76] and free [77] out-of-plane vibrations with higher effects have been also considered.

Some special analytical techniques have been developed. The general dynamic slope-defection equations for circular curved beams with constant cross section in terms of rotation, angle of twist, and vertical displacement have been derived [78]. Their use was illustrated for a two-span curved beam. A multi-span frame structure was treated in a similar way [79-80]. Classical equations of motion and admissible boundary conditions were used to derive a dynamic three-moment equation for continuous curved beams [81]. The equation was used to study the bending waves in periodically supported beams.

A combination of an iterative procedure and an initial value integration technique was used in single- and multi-span curved beams [82]. The method of internal constraints has been applied to in-plane and out-of-plane vibrations of toroids [83, 84], free-free half toroids [85, 86], and solutions for phase velocities of circular helices. A simple analysis of induced stresses and natural frequencies of flexural vibrations of initially slightly bent slender bars, subjected to prescribed axial end displacements, has been presented [87]. Asymptotic integration of governing differential equations proved to be a successful tool for calulating higher eigenvalues of in-plane curved beams [88].

The methods of characteristics [89] and finite differences [90] have been used to solve Morley's equations for beams subjected to pulse type loading. Longitudinal-flexure waves in curved beams [91], dispersion of elastic waves in a curved mechanical waveguide [92], and stress-pulse dispersion in a helical spring [93] have been investigated. A special group technique [94, 95] and first order perturbation theory [96] were employed to study degenerate pairs of natural frequencies of thin circular rings.

Acoustically-induced vibration [97], coupled torsional-longitudinal vibration of slender beams under aerodynamic forces in a centrifuge force field [98], vibrations of rings with unrestrained cross sections [99], small vibrations of spatial rods in surrounding flow media [100], and rotating thick curved beams [101] have also been studied. Optimization studies [102, 103] and optimization of the shape of the central line with respect to the lowest frequency [104] have been reported. Flexural vibrations of multi-span shafts with an initial curvature [105], multi-span structures [106, 107], and behavior of curved structures under periodic loading [108-111] have been analyzed.

Analytical techniques, based on transfer matrix methods, were presented for studying the forced vibrations of cylindrically curved multi-span structures [112]; damping was introduced, and the possibility of modeling a complete skin-stringer fuselage structure by multi-span curved beams was discussed. The state vector transfer matrix approach [113] proved to be an effective tool for investigating in-plane and out-of-plane vibrations of arbitrarily shaped plane bars. The steady-state in-plane [114] and out-of-plane [115, 116] response of curved Timoshenko beams with internal damping to a sinusoidally varying point force or moment has been determined using the transfer matrix approach. The method has been applied to free-clamped nonuniform bars with a circular, elliptical, or parabolical neutral axis excited at the free end.

FINITE ELEMENT METHOD

Three curved beam elements have been investigated relative to the problem of radial vibrations of curved beams [117]. The elements were used to investigate the variation of the six lowest natural frequencies of beams with simply-supported, hinged, and clamped ends. These results were experimentally confirmed [118]; moreover, the frequencies and modes of a constant curvature five-bay beam on hinged supports were also determined.

The finite element displacement method was utilized to analyze circular arches [119]. Dynamic stiffness matrices have been derived for the in-plane vibration of thick circular rings [120] where secondary effects have been introduced. Natural frequencies of a curved beam with a tip mass were studied using both the finite element and experimental methods [121]. The flexible blade of auto-cooling fans was modeled as a curved beam with a tip mass [121]. Great effort has been exerted to develop suitable curved finite elements; useful information is available [122-144].

METHODS DEALING WITH NONLINEAR OSCILLATIONS

Nonlinear oscillations of elastic systems with curvature have also received attention in the literature [145-162]. Emphasis was on circular rings [145-146] and shallow arches [147-150]. Integro-differential equations of motion were solved by the Bubnov method for beams and arches [151] as well as for in-plane vibrations of a ring [152]. Geometrically nonlinear theories of spatially curved rods have been presented [153, 154].

The effects of a nonlinear neutral axis stretching on the non-planar free and forced vibrations of a beam with immovable ends have been studied [155, 156]. The effects of flexural-torsional coupling and nonlinear curvature on the oscillation of a fixed-free beam, attached to either rigid or flexible unsymmetric supports, have also been investigated [157]. A set of mathematically consistent governing differential equations of motion has been derived [158, 159]; the nonlinear, non-planar dynamics of an inextensional beam were also described. The parametric excitation of a tensioned bar with initial curvature has been discussed [160].

HYBRID METHODS USED FOR THIN-WALLED BEAMS

The increasing use of curved thin-walled beams in highway bridges, ships, and aircraft has resulted in considerable effort being directed toward developing accurate methods for analyzing the dynamic behavior of such structures [163-183]. The dynamic response under moving loads was examined for simply supported curved girders [164, 165] using Vlasov's theory [163].

Free flexural vibrations including damping [166, 167], forced vibrations of two-span curved girders of doubly symmetric cross section [168], and the general case of triple coupling in curved girders of asymmetric cross section [169] have also been analyzed. Equations of thin rings including warping effects and rotatory inertia have been explored in detail [170]; generalized displacements for some problems have been derived [171]. Rutenberg [172] presented two simple methods for calculating the natural frequencies of out-of-plane vibrations of curved thin-walled beams for several support conditions; he solved coupled equations given by Dabrowski [173].

Equations for quadrupole coupling between two flexural, tangential, and torsional vibrations of curved thin-walled girders of asymmetric cross section have been derived [174]. Section warping was included, but axial forces, rotatory inertia, and structural damping were neglected. A modified transfer-matrix method was applied to harmonically-excited damped-space vibrations of thin-walled box structures as well as to box structures subjected to non-periodic dynamic loads [175]. Finally, sandwich structures, damped and undamped, with closed and open cross sections have been widely investigated [184-193].

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LITERATURE REVIEW: survey and analysis of the Shock and Vibration literature

The monthly Literature Review, a subjective critique and summary of the literature, consists of two to four review articles each month, 3,000 to 4,000 words in length. The purpose of this section is to present a "digest" of literature over a period of three years. Planned by the Technical Editor, this section provides the DIGEST reader with up-to-date insights into current technology in more than 150 topic areas. Review articles inlcude technical information from articles, reports, and unpublished proceedings. Each article also contains a minor tutorial of the technical area under discussion, a survey and evaluation of the new literature, and recommendations. Review articles are written by experts in the shock and vibration field.

This issue of the DIGEST contains an article about the response of nonlinear mechanical systems to random excitation.

Dr. J.B. Roberts of the University of Sussex, Sussex, England has written Part I of a two-part survey which outlines recent progress in applying the theory of Markov processes, in particular the Fokker-Planck-Kolmogorov equation, to the problem of predicting the response of nonlinear systems to random excitation. A variety of approximate methods of solution are discussed; emphasis is on applications.

RESPONSE OF NONLINEAR MECHANICAL SYSTEMS TO RANDOM EXCITATION
PART I: MARKOV METHODS

J.B. Roberts*

Abstract. Part I of two-part survey outlines recent progress in applying the theory of Markov processes, in particular the Fokker-Planck-Kolmogorov equation, to the problem of predicting the response of nonlinear systems to random excitation. A variety of approximate methods of solution are discussed; emphasis is on applications.

The general theory for predicting the response of linear mechanical and structural systems to random excitation is well established and can be found in a number of introductory books [1-4]. For Gaussian excitation processes the theory allows routine evaluation of the parameters of the corresponding response processes. Unfortunately, however, all real systems have some degree of nonlinearity [5-7]; the result is that response processes deviate from the Gaussian form, particularly at the extremes of the distribution. Such deviations can have a pronounced effect on the probability of system failure [8-10]. It is thus a matter of considerable importance to develop methods for predicting response statistics in the nonlinear case.

Over the years a number of approaches to this problem have evolved:

- Markov methods, based on the Fokker-Planck-Kolmogorov (FPK) equation
- equivalent linearization methods
- perturbation methods
- functional series representations
- simulation methods (digital and analog)

A thorough review of the state of the art of most of these methods was given almost ten years ago [11]. Other reviews [12, 13] of more limited scope also appeared about this time [12, 13]; an earlier review is also useful [14]. However, significant progress has been made since 1970, and it seems appropriate to attempt the present review of the literature. The review is in two parts: Part I deals with Markov methods; Part II covers the remaining methods listed above.

For the sake of completeness the review contains a brief historical background. The main objective is to indicate current trends in research and the range of problems that have been solved thus far, rather than to attempt a completely exhaustive bibliographic survey. Moreover, emphasis is placed on applications rather than on questions concerning the existence and uniqueness of solutions. A good account of the mathematical background has been given by Caughey [11].

This review is deliberately restricted to situations in which parametric excitation is absent. A comprehensive survey of the response of systems to stochastic parametric excitation has been published [15].

EQUATIONS OF MOTION

For an n^{th} order mechanical or structural system responding to stationary random excitation the equations of motion can be cast into the matrix form

$$\dot{\underset{\sim}{Z}} = \underset{\sim}{a}(\underset{\sim}{Z}) + \underset{\sim}{A}.\underset{\sim}{Y}(t) \qquad (1)$$

$\underset{\sim}{Z}$ is an n vector containing the displacements and velocities of the system; $\underset{\sim}{A}$ is n x n matrix. $\underset{\sim}{Y}(t)$ is an n vector containing the excitation processes. It is assumed throughout that $\underset{\sim}{A}$ is independent of $\underset{\sim}{Z}$; i.e., parametric effects are excluded.

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If the elements of $\underset{\sim}{Y}(t)$ are broad-band in character, they can, in many cases, be approximated satisfactorily in terms of white noises [16, 17]. Thus

$$\underset{\sim}{Y}(t) = \underset{\sim}{K}.\underset{\sim}{\xi}(t) \tag{2}$$

$\underset{\sim}{K}$ is an n x n matrix; $\underset{\sim}{\xi}(t)$ is an n vector of independent, unit white noises, with a correlation matrix

$$E\{\underset{\sim}{\xi}(t)\underset{\sim}{\xi}'(t+\tau)\} = \underset{\sim}{I}\delta(\tau) \tag{3}$$

$\underset{\sim}{I}$ is the unit n x n matrix. For simplicity the mean of $\underset{\sim}{\xi}(t)$ will be assumed to be a zero vector; the extension to the case of nonzero means is straightforward [18].

Although the introduction of the white noise approximation is useful, it has the disadvantage that Equation (1) must be carefully interpreted. For example, $\dot{\underset{\sim}{Z}}$ now exists almost nowhere [19]. One suitable interpretation, and that adopted by many authors, is to treat Equation (1) as an Itô equation [19-21]; it is then written in the standard integral form

$$d\underset{\sim}{Z} = \underset{\sim}{a}(\underset{\sim}{Z})\, dt + \underset{\sim}{B}\, d\underset{\sim}{W} \tag{4}$$

where

$$\underset{\sim}{B} = \underset{\sim}{A}.\underset{\sim}{K} \tag{5}$$

and $\underset{\sim}{W}$ is an n vector of unit Wiener processes, such that (formally)

$$\underset{\sim}{\xi}(t) = \frac{d\underset{\sim}{W}}{dt} \tag{6}$$

THE FPK EQUATION

When Equation (1) is approximated as Equation (4), it follows that $\underset{\sim}{Z}$ is an n dimensional Markov process [19, 21], with a transition probability density function $p(\underset{\sim}{Z}|\underset{\sim}{Z}_0;t)$ governed by the diffusion equation

$$\frac{\partial p}{\partial t} = Lp \tag{7}$$

where

$$L = -\sum_{i=1}^{n} \frac{\partial}{\partial Z_i}[a_i(\underset{\sim}{Z})\cdot] + \frac{1}{2}\sum_{i}^{n}\sum_{j=1}^{n} D_{ij}\frac{\partial^2}{\partial Z_i \partial Z_j} \tag{8}$$

and

$$\underset{\sim}{D} = [D_{ij}] = \underset{\sim}{B}\,\underset{\sim}{B}' \tag{9}$$

Because Equation (7) is associated with the work of Fokker [22], Planck [23], and Kolmogorov [24], it is generally referred to as the Fokker-Planck-Kolmogorov (FPK) equation (sometimes known as the forward Kolmogorov equation).

The initial condition for $p(\underset{\sim}{Z}|\underset{\sim}{Z}_0;t)$ is

$$\lim_{t\to 0} p(\underset{\sim}{Z}|\underset{\sim}{Z}_0;t) = \delta(\underset{\sim}{Z}-\underset{\sim}{Z}_0) \tag{10}$$

and a stationary solution

$$w(\underset{\sim}{Z}) = \lim_{t\to\infty} p(\underset{\sim}{Z}|\underset{\sim}{Z}_0;t) \tag{11}$$

usually exists; $w(\underset{\sim}{Z})$ is obtained as the solution of Equation (7) with $\partial p/\partial t = 0$; that is,

$$L\, w = 0 \tag{12}$$

The FPK approach outlined above was first developed to study the phenomenon of Brownian motion and originates in the pioneering work of Einstein [25]. Excellent reviews of early work in this area have been published [26, 27]. The FPK method is also closely related to the theory of random walks [26, 28], and in this respect its origins can be traced back to Rayleigh [29]. An interesting historical survey of the FPK method has been published [30].

EXACT SOLUTIONS

A general, closed-form solution to Equation (7) has yet to be found, but a series solution can be obtained in terms of eigenfunctions. If the L operator has a discrete set of eigenfunctions $v_i(\underset{\sim}{Z})$ and corresponding eigenvalues λ_i that satisfy

$$(L + \lambda_i)v_i = 0 \quad (i = 0,1,\ldots) \tag{13}$$

then the transition density function [11, 31] is given by

$$p(\underset{\sim}{Z}|\underset{\sim}{Z}_0;t) = \sum_{i=0}^{\infty} e^{-\lambda_i t} v_i(\underset{\sim}{Z})v_i^*(\underset{\sim}{Z}_0) \tag{14}$$

The set of eigenfunctions $v_i^*(\underset{\sim}{Z})$ relate to the adjoint of L and are orthogonal to the set $v_i(\underset{\sim}{Z})$; that is,

$$\int v_i(\underset{\sim}{Z})v_j^*(\underset{\sim}{Z})d\underset{\sim}{Z} = \delta_{ij} \tag{15}$$

Here λ_0 equals 0 and $v_0(Z)$ equals $w(\underset{\sim}{Z})$, the stationary solution ($v_0^*(\underset{\sim}{Z})$ = 1). In some applications the spectrum of eigenvalues has a continuous portion; Equation (14) must be modified accordingly [31].

Because $p(\underset{\sim}{Z}|\underset{\sim}{Z}_0;t)$ is a complete description of $\underset{\sim}{Z}(t)$, it is possible to evaluate any statistic of $\underset{\sim}{Z}(t)$ after $p(\underset{\sim}{Z}|\underset{\sim}{Z}_0;t)$ is known. In particular the spectral density matrix can be evaluated [11,31].

First order systems. For n = 1 [17,31] Equation (4) reduces to a scalar equation and Equation (14) simplified to

$$p(z|z_o;t) = \sum_{i=o}^{\infty} e^{-\lambda_i t} \frac{v_i(z)v_i(z_o)}{v_o(z_o)} \tag{16}$$

Analytical expressions for $v_i(Z)$ and λ_i have been found for only a few special cases [31-37]. However, a general expression for the stationary density function can easily be found from Equation (12), where

$$L = -\frac{\partial}{\partial Z} a(Z). + \frac{B^2}{2}\frac{\partial^2}{\partial Z^2} \tag{17}$$

The result is [17]

$$w(Z) = \frac{C}{B^2}\exp\{\frac{2}{B^2}\int_0^Z a(y)dy\} \tag{18}$$

C is a normalization constant.

Second order systems. An oscillator having nonlinear damping and stiffness characteristics and driven by white noise is governed by the differential equation

$$\ddot{X} + g(X,\dot{X}) = K\,\xi(t) \tag{19}$$

where g( ) is an arbitrary nonlinear function of the displacement X and velocity $\dot{X}$; K is a constant.

Equation (19) can be cast into the matrix form of Equation (1) if

$$\underset{\sim}{Z} = \begin{bmatrix} X \\ \dot{X} \end{bmatrix} = \begin{bmatrix} Z_1 \\ Z_2 \end{bmatrix},\quad \underset{\sim}{a}(\underset{\sim}{Z}) = \begin{bmatrix} Z_2 \\ -g(Z_1,Z_2) \end{bmatrix},\quad \underset{\sim}{Y}(t) = \begin{bmatrix} 0 \\ K\xi(t) \end{bmatrix} \tag{20}$$

and $\underset{\sim}{A}$ is a unit matrix. Hence from Equations (7) and (8) the appropriate FPK equation is

$$\frac{\partial p}{\partial t} = -Z_2\frac{\partial p}{\partial Z_1} + \frac{\partial}{\partial Z_2}(gp) + \frac{K^2}{2}\frac{\partial^2 p}{\partial Z_2^{\,2}} \tag{21}$$

A complete, exact analytical solution to Equation (21) has been found only in the linear case [27]. However, if attention is restricted to the stationary density function, $w(\underset{\sim}{Z})$, there is a well-known result for the case of linear damping and arbitrary nonlinear stiffness. If

$$g = \beta Z_2 + h(Z_1) \tag{22}$$

Equation (21) becomes Kramer's Equation [38], which has the stationary solution

$$w(\underset{\sim}{Z}) = C\exp(-\gamma E) \tag{23}$$

where $\gamma = 2\beta/K^2$; C is another normalization constant and

$$E = \frac{Z_2^{\,2}}{2} + \int_0^{Z_1} h(\xi)\,d\xi \tag{24}$$

Equation (24) is the total energy (kinetic plus potential) of the oscillator. Equation (23) has been obtained independently by many authors [38-41].

The basic results due to Rice [46] can be used to deduce the effect of stiffness nonlinearities on a variety of important response statistics from Equation (23); these include level crossing rates and peak distributions [42-45]. Several particular types of nonlinearity have been studied using Equation (23); these include the Duffing oscillator [43, 45, 47-49], an oscillator with set-up springs [50], oscillators with tangent elasticity characteristics [51,52], and other specific forms of $h(Z_1)$ [40, 53]. Certain continuous systems have also been approximated as single-degree-of-freedom systems with nonlinear stiffness characteristics [54-57].

Exact solutions for systems with nonlinear damping can be found only in certain very special cases. Caughey [58] has shown that if

$$g = \beta Z_2 f(E) + h(Z_1) \tag{25}$$

then

$$w(\underset{\sim}{Z}) = C\exp\{-\gamma\int_0^E f(\xi)\,d\xi\} \tag{26}$$

This is clearly a generalization of Equation (23). Another particular solution has been given by Lin [3]. These results can be used as comparison tests for approximate solutions. Equation (26) has been employed to estimate the distribution of the response for other forms of damping nonlinearity; a generalized version of the equivalent linearization procedure [59, 60] is used.

Higher order systems. The result given by Equation (26) can be generalized to higher order systems. Let the equations of motion be of the form

$$m_i \ddot{x}_i + \sum_{i=1}^{n} \beta_{ij} \dot{x}_i f(E) + \frac{\partial U}{\partial x_i} = n_i \quad (i = 1,2,\ldots,n) \tag{27}$$

U is the potential energy function of the system;

$$E = \frac{1}{2} \sum_{i=1}^{n} m_i \dot{x}_i^{\,2} + U \tag{28}$$

Equation (28) is the total energy of the system. β_{ij} and m_i are constants; n_i are correlated white noises; the correlation matrix is given in Equation (29).

$$E\{n_i(t)\, n_j(t+\tau)\} = R_{ij}\delta(\tau) \tag{29}$$

It has been shown by Fuller [30] that, with the very severe restriction given in Equation (30),

$$2\,\frac{\beta_{ij}}{R_{ij}} = \gamma \quad (i, j, = 1, 2 \ldots, n) \tag{30}$$

the stationary distribution of Z is again given by Equation (26). This result is the most general exact solution thus far obtained for higher order systems. Special cases of this distribution were obtained earlier by Ariaratnam [61, 62], Caughey [45, 58], and Bolotin [63, 64].

Unfortunately, the restriction given by Equation (30) is realistic for only a few practical problems. For beams and plates subjected to spatially and temporally uncorrelated excitation Equation (30) does apply [63]; results for the case of linear damping have been obtained [65-67].

For linear damping (f(E) - 1) Equation (26) reduces to Equation (23); again E is given by Equation (28). The result is the Maxwell-Boltzmann distribution, which is well known in the field of statistical mechanics [68]. Fuller [30] has given an interesting account of the relationship between statistical mechanics, Hamiltonian mechanics, and the exact solutions of the FPK equation.

APPROXIMATE SOLUTIONS

For the majority of nonlinear systems of practical concern analytical solutions are not available; it is necessary to resort to approximations to obtain the distribution of the response.

Iterative methods. A general iterative procedure for solving the FPK equation [11, 69-71] is based on the parametric method for studying the existence and uniqueness of solutions of partial differential equations.

Suppose that $p_0(\underset{\sim}{Z}|\underset{\sim}{Z}_0;t)$ is an initial estimate for the solution of Equation (7). Mayfield [69] has shown that the sequence

$$p_{n+1}(\underset{\sim}{Z}|\underset{\sim}{Z}_0;t) = p_0(\underset{\sim}{Z}|\underset{\sim}{Z}_0;t) + \int_0^t \int_\Omega p_n(\underset{\sim}{Z}|\underset{\sim}{y};t-\sigma)\, L' p_0(\underset{\sim}{y}|\underset{\sim}{Z}_0;\sigma)\, d\underset{\sim}{y}\, d\sigma \tag{31}$$

can be used to successively refine p_0; that is, p_n approaches the solution to Equation (7) as n increases. Here

$$L' = L - \frac{\partial}{\partial t} \tag{32}$$

The integration range for $\underset{\sim}{y}$, Ω, is generally $-\infty$ to ∞. Caughey has examined the convergence of such an iterative scheme for a special case [11].

Application of Equation (31) requires a suitable initial estimate, p_0. For systems with small nonlinearity the linear Gaussian solution can be used for p_0. This case was discussed in some detail by Mayfield [69] who evaluated the term $L'p_0$ in Equation (31). If only $w(\underset{\sim}{Z})$ is required, Equation (31) can be simplified; further simplifications are possible if only the moments of the response are needed [69].

In common with many other methods, the degree of computational effort involved in implementing Equation (31) – even if only one iteration is required – increases rapidly as the order of the system increases. It has yet to be applied to nonlinear mechanical systems but is a potentially useful method for improving approximate solutions and merits further study.

Series expansion methods. It was pointed out earlier that the solution to Equation (7) can be written in terms of the eigenfunction expansion of Equation (14) but that there are few cases in which the eigenfunctions v_i and v_i^* can be obtained analytically. Atkinson [31] proposed an adjoint variational method to estimate v_i and v_i^*; the method assumes approximate eigenfunctions of the form shown in Equation (33).

$$v_i = \sum_{j=1}^{N} C_j U_j \ , \qquad v_i^* = \sum_{j=1}^{N} C_j^* U_j^* \tag{33}$$

U_j, U_j^* are arbitrary, linearly independent trial functions; the constants C_j, C_j^* and the eigenvalues are found by solving an appropriate matrix equation [11, 31]. Estimates of the correlation function and spectrum of the response of several second order systems have been obtained by using polynomial trial functions [31]. Comparison with corresponding simulation estimates showed that the method gave good estimates without excessive computation, provided that the damping was not very small. The latter restriction is due to the fact that the FPK becomes singular as damping approaches zero. The variational method has been used previously [37] for first order systems. An alternative, perturbation method of estimating the eigenvalues has been outlined [11].

A different eigenfunction expansion technique has been suggested by Stratonovitch [17]; he considered in some detail the case of a second order system. $\underset{\sim}{Z} = [Z_1, Z_2]$ and an expansion of the form shown in Equation (34) is assumed.

$$p(\underset{\sim}{z}|\underset{\sim}{z}_0;t) = \sum_{i,j=0}^{\infty}\sum^{\infty} T_{ij}(t)\, X_i(z_1) Y_j(z_2) \tag{34}$$

The eigenfunctions X_i and Y_j are obtained from the solution of two ordinary, uncoupled differential equations; the time functions T_{ij} are found by solving a system of simultaneous equations. A pertürbation method for solving the equations is discussed for the case in which the mass coefficient is small.

Another series expansion approach has been developed by Bhandari and Sherrer [72]. They considered the stationary solution $w(Z_1, Z_2)$ for a second order system and represented it as the expansion

$$w(Z_1,Z_2) = \sum_{i,j}^{N}\sum^{N} A_{ij}\, G_i(Z_1)\, G_j(Z_2) \tag{35}$$

G_i ( ) are related to Hermite polynomials. The Galerkin method was used to determine the coefficients A_{ij}. The rate of convergence of the series solution was examined by comparing results with the known exact solution for a Duffing oscillator with linear damping; see Equation (23). The method was extended to deal with two-degree-of-freedom systems and compared with a known exact solution of Ariaratnam [61].

Wen [73] extended this Galerkin method and obtained nonstationary response statistics; he allowed the terms in the series expansion to be time dependent. Results were obtained for the transient response of a Duffing oscillator to stationary white noise. For a yielding system of the Ramberg-Osgood type an equivalent, nonlinear, non-hysteretic system was first constructed. Wen [74] later showed that the method can be applied directly to second-order hysteretic systems by increasing the dimension of the FPK equation from two to three. Good agreement was obtained with simulation estimates for the case of an oscillator with bilinear hysteresis.

Random walk analogy. Another approach to solving the FPK equation is to use some kind of finite difference numerical scheme. Toland and Yang [75] exploited the analogy between discrete random walks and continuous diffusion processes [26, 28] and derived fairly simple finite difference schemes for the numerical diffusion of probability mass. They considered second order oscillators and, by the introduction of an absorbing barrier into the phase plane, were able to obtain estimates of first passage failure for different kinds of nonlinear stiffness. This method has also been used to compute mean fatigue damage statistics [76].

Other methods for numerically solving the FPK equation have been discussed [77, 78].

Stochastic averaging methods. When damping is fairly light and the response processes of interest are narrowband in nature, the powerful method of stochastic averaging due to Stratonovitch [17] can be used. This method is a generalization of the deterministic averaging procedure described by Bogoliubov and Mitropolsky [79]. A rigorous foundation for the method has been given [80-82].

The method is particularly useful in dealing with systems with nonlinear damping, for which exact solutions are generally unavailable. As an illustration, consider a second order system with the equation of motion

$$\ddot{X} + \beta f(\dot{X}) + \omega_o^2 X = F(t) \tag{36}$$

where ω_o is the undamped natural frequency, β is a small parameter, $f(\dot{X})$ is a damping term (assumed to be odd), and $F(t)$ is a stationary random process with zero mean. If an amplitude process $A(t)$ and a phase process $\phi(t)$ are defined by

$$X = A \cos \Phi, \quad \dot{X} = -\omega_o A \sin \Phi \tag{37}$$

where

$$\Phi = \omega_o t + \phi \tag{38}$$

Equation (36) can be recast as a pair of first-order equations in A and ϕ; thus

$$\dot{A} = \frac{\beta f(-\omega_o A \sin\Phi) \sin\Phi}{\omega_o} - \frac{F(t) \sin\Phi}{\omega_o} \tag{39}$$

$$\dot{\phi} = \frac{\beta f(-\omega_o A \sin\Phi) \cos\Phi}{A\omega_o} - \frac{F(t) \cos\Phi}{A\omega_o} \tag{40}$$

The right hand sides of Equations (39) and (40) depend not only on $A(t)$, $\phi(t)$, and $F(t)$ but also explicitly on time, through the terms $\sin \Phi$ and $\cos \Phi$. These terms produce small, rapid oscillations that are superimposed on the relatively large but slowly varying components of $A(t)$ and $\phi(t)$. Thus, to a first approximation, equations (39) and (40) can be averaged by eliminating the oscillatory terms. Following the method of Stratonovitch [17], the averaged equations are [83]

$$\dot{A} = -\frac{\beta}{\omega_o} G(A) + \frac{\pi S(\omega_o)}{2A\omega_o^2} - \left[\pi S(\omega_o)\right]^{\frac{1}{2}} \frac{\xi_1(t)}{\omega_o} \tag{41}$$

$$\dot{\phi} = -\left[\pi S(\omega_o)\right]^{\frac{1}{2}} \frac{\xi_2(t)}{A\omega_o} \tag{42}$$

Here $\xi_1(t)$, $\xi_2(t)$ are mutually independent unit white noises; $S(\omega_o)$ is the spectrum of $F(t)$.

$$S(\omega) = \frac{1}{2\pi} \int_{-\infty}^{\infty} E\{F(t)\, F(t+\tau)\} \cos\omega\tau \, d\tau \tag{43}$$

evaluated at ω_o.

$$G(A) = -\frac{1}{2\pi} \int_0^{2\pi} f(-\omega_o A \sin\Phi) \sin\Phi \, d\Phi \tag{44}$$

Equation (41) is uncoupled from Equation (42) and can be cast into the standard form of Equation (4), with $Z = A(t)$, a scalar quantity. A one-dimensional FPK equation for $A(t)$ is thus obtained.

$$\frac{\partial p}{\partial t} = \frac{\partial}{\partial A}\left[\left\{\frac{\beta}{\omega_o} G(A) - \frac{\pi S(\omega_o)}{2A\omega_o^2}\right\} p\right] + \frac{\pi S(\omega_o)}{2\omega_o^2} \frac{\partial^2 p}{\partial A^2} \tag{45}$$

The stationary solution to Equation (45), $w(A)$, can be obtained explicitly; see Equation (18). Moreover, it follows from Equations (41) and (42) that $A(t)$, $\phi(t)$ is a joint, two-dimensional Markov process with an appropriate FPK equation. From the form of this equation [83] the joint stationary distribution of $A(t)$ is of the form

$$w(A, \phi) = C.w(A) \tag{46}$$

(i.e., the phase is uniformly distributed) and from the normalization condition, $C = 1/2\pi$. Equation (46) can be readily transformed into an expression for the joint distribution of $X(t)$ and $\dot{X}(t)$, from which a variety of response statistics can be evaluated. For certain forms of nonlinear damping this method has been shown to agree very well with corresponding simulation estimates, provided that damping is not excessive [83]. This approach has been extended to deal with oscillators with hysteretic restoring forces [84, 85] and with parametric restoring forces [86]. Results relating to the amplitude process alone have been found using this method [87-89].

For oscillators with both nonlinear damping and stiffness, Iwan and Spanos [90] have proposed an extension of the procedure outlined above, in which the frequency ω_0 – which appears in Equation (37) – is allowed to become amplitude dependent. The resulting FPK equation is solved by a perturbation technique [91]; applications include the Duffing oscillator [91] and hysteretic systems [92]. The extension proposed by Iwan and Spanos does not give the exact stationary solution in cases in which it is available and can also be criticized with regard to the consistency of the approximations involved [93]. Another interesting attempt at allowing for nonlinear stiffness effects through an amplitude-dependent frequency has been made [94] but is open to similar objections.

A different approach to dealing with oscillators with combined nonlinear damping and stiffness has been developed [8, 10, 95-97]; see also the book by Stratonovitch [17]. In this approach the energy envelope E – see Equation (29) – is approximated as a one-dimensional Markov process. It has been shown to give good agreement with simulation results [8, 10, 95, 97] and has the advantage of being in complete agreement with the few known exact solutions.

Moment closure methods. A set of equations for the moments of the response process can be obtained by suitably integrating the FPK equation [98]. For nonlinear systems the equations for lower order moments always contain at least one term relating to a higher order moment; in other words an infinite set, or heirarchy, of coupled moment equations.

To solve this set it is necessary to introduce a closure approximation; that is, assume some relationship between the higher order moments and the lower order moments. Various closure methods have been proposed [98-104] and tested in special cases. A good, recent example of this approach is the work of Bover [103], who used a quasi-moment truncation scheme. He obtained good agreement with simulation estimates for the case of a Duffing oscillator.

NONSTATIONARY RESPONSE

Many of the techniques discussed previously can be used to study nonstationary problems. For studying the transient response to suddenly applied stationary excitation the series expansion method of Wen [73, 74] and the numerical scheme of Toland and Yong [75, 76] can be used. It is also possible to use the method of stochastic averaging for lightly damped systems; this considerably reduces computer effort. In a recent paper [105] this approach was used to estimate the transient response statistics for several nonlinear oscillators. The time-dependent solutions of the appropriate FPK equations were obtained by using a random walk analogy. Good agreement was obtained with digital simulation estimates.

The method of stochastic averaging can also be adapted fairly easily to modulated random excitation [106].

RELIABILITY PROBLEMS

In many cases it is necessary to predict the probability that a system will not fail, in some sense, during a certain interval of time. For an n^{th} order system suppose that there is a safe region in phase space and that failure corresponds to a response trajectory leaving the safe region. The problem of predicting the distribution of the time T required for the response $\underset{\sim}{Z}$ to exit from the safe region is generally known as the first-passage problem.

When $\underset{\sim}{Z}$ is a Markov process, the first passage can be solved, at least in principle, by using the adjoint of the FPK equation [8, 17, 63] – known as the backward Kolmogarov equation. Integrate this equation to obtain equations for the moments of the first passage time [95]. A review of this and other methods for solving the first passage problem is currently in preparation [107].

RECOMMENDATIONS

A general feature of the various proposed methods for solving the FPK equation is that the computational effort increases enormously as the order of the system increases. Thus it is not difficult with present-day computers to generate solutions for single-degree-of-freedom systems; however, it is much more difficult to solve for systems with several degrees of freedom. The method of stochastic averaging is very useful for reducing the computational effort required because it essentially reduces the dimension of the FPK equation. Much effort thus far has been directed at the application of the stochastic averaging method to single-degree-of-freedom systems with considerable success. It is recommended that efforts be made to extend this approach to multi-degree-of-freedom systems. Other approaches to reducing the dimension of the FPK equation for higher order systems by suitable approximations should also be investigated.

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BOOK REVIEWS

OFFSHORE STRUCTURES ENGINEERING

F.L.L.B. Carneiro, A.J. Ferrante,
and C.A. Brebbia, Editors
Gulf Publishing Co., Houston, Texas, 1979

This book is the proceedings of the International Conference on Offshore Structures Engineering held at COPPE, Federal University of Rio de Janeiro, Brazil in September, 1977. This reviewer found this book interesting and educational reading.

There is a major attempt underway in Brazil to find and develop their offshore oil resources. Much detailed planning and organization have gone into this program. Given as background in Part I is the success of the U.K. North Sea Offshore Development. The remainder of the book is devoted to offshore engineering.

Part II on analysis of offshore structures is the most substantial with eight papers. Six of the papers are by U.K. authorities; the other two are by a Norwegian and a Brazilian. The papers are technical in nature and written so that the reader can do an analysis. Some analytical background would certainly be useful.

Part III on waves and other fluid induced forces contains five papers, two by people from the U.K. This section provides loading input to the structural analyst and contains considerable discussion of structural interaction.

Part IV, which covers soil problems, strikes this reviewer as a bit limited although one paper discussed the effect of soil properties. The other paper considers offshore pipe.

Part V, Design and Construction, consists of three papers: design criteria and safety codes, offshore risk and its management, and an example of one type of gravity platform used in the North Sea.

Part VI has six papers on positioning and instrumentation – an interesting problem that had not occurred to this reviewer.

Overall this 424 page book provides a good introduction to the design of offshore structures. The sponsors of the conference organized an interesting and informative conference. The publishers are to be congratulated for publishing it. This book is a good introduction to the problem of designing an offshore structure and provides a basis for proceeding with a design.

The book is written in English and was published by Gulf Publishing Company, Houston, Texas, in 1979.

K.E. McKee
Director, Engineering Mechanics Division
IIT Research Institute
Chicago, Illinois

STOCHASTIC PROBLEMS IN DYNAMICS

B.L. Clarkson, Editor
Fearon-Pitman Publ., Belmont, California

Each year stochastic problems assume a more important role. This fascinating subject is for the engineer seeking practical interpretation of dynamic problems of a stochastic nature and for the applied mathematician formulating the theory of stochastic systems. This symposium, sponsored by ITUM, brought together 60 of the world's leading workers in the general area of stochastic problems in dynamics. Each of the 30 papers is accompanied by an edited version of the discussion that followed each presentation.

The initial papers discuss decision theory, stationary Gaussian colored noise, closed form expressions for first and second moments of state variables, and stability and criteria of higher moments for finite time intervals.

Papers in the mathematical section consider various topics. The time variable of the Weiner process is studied using a space coordinate to obtain a model for randomly distributed loading. The method of stochastic averaging is applied to multi-degree-of-freedom systems in mixed deterministic and broad-band noise. The stochastic averaging theorem is used as an alternative for the method of equivalent linearization applied to nonlinear oscillators with random excitation. A second averaging method is applied to time-varying coefficients of the Fokker-Planck equation and an optimal stochastic control problem for a linear dynamic system.

In earthquake resistance of buildings, the probabilistic structure of the random process is poorly known. One paper presents a method that furnishes proper bounds for the first passage problem, always a favorite topic. Probabilities are predicted for a lightly damped vibrating system containing both linear and nonlinear damping and excited by white noise. A second paper considers the upper and lower bounds being obtained and applies them to calculations of the reliability of structures under seismic excitation.

Two papers discuss new methods for processing random data by conditioning the output of structures with many degrees of freedom and by removing the coherent components. In a paper on bridge problems aerodynamic characteristics are determined using time domain system identification, and the response to moving random loads is assessed.

Other applied papers are concerned with a uniform structure excited by wide band random excitation and disappearance of boundaries that become irregular in shape; prediction of fatigue load cycles of an aircraft flying through turbulence; and instability when flutter accompanies random vibration of a plate in supersonic flow. The response of a periodically supported beam to supersonic boundary layer fluctuation is reported, as is an interesting application of nonlinear problems to sheet stringer panels subjected to constraints in stress and fatigue life. One paper considers time domain methods for calculating nonstationary random response of vehicles traveling with variable velocity over rough roads; the profile is assumed to be spatially statistically homogeneous. Another paper deals with stochastic response to ships steering when the course of the ship is subjected to nonlinear response of the sea.

The various papers in this volume are of high quality and should be read by those interested in stochastic problems. The reviewer would have preferred more papers of an experimental nature with application to interval reactors and space type vehicles. The editor and authors are to be complimented.

H. Saunders
General Electric Company
Schenectady, New York

VIBRATIONS OF ELASTIC STRUCTURAL MEMBERS

E.B. Magrab
Sijthoff & Noordhoff, Alphen aan den Rijn, The Netherlands; 1979; $60.00

Reviewing this book was like spending a pleasant evening with an old friend. Discussing old times and rehearing old jokes is a charming, if not useful, way to spend an evening. Unfortunately that is not what one expects in reading a new technical book.

The first thing I checked was the copywrite date and sure enough it says 1979, which makes the book a rational subject for review. At that stage I read the preface and found the secret. The last paragraph from the preface:

"The book is an outgrowth of lecture notes prepared for an advanced graduate level course taught from 1965 to 1974 in the school of Engineering and Architecture at the Catholic University of America. It was during this period, as a full time faculty member, that the majority of the work on the manuscript was done. To the many students whose comments and suggestions over the years helped shape this final version, my appreciation and my thanks. And lastly my thanks to Carolyn Smith for her expert typing of the manuscript."

The presentation used in the book is typical of that used in graduate school starting in the 1950s and common in the 1960s. Computers were developing rapidly in the 1960s, and it became logical to use computers to develop approaches. The result has been considerable evolution in the approach to vibration problems.

The book does a reasonable job, but it is too late. I assume friends and students of Dr. Magrab will want the book. Perhaps there are also purists who want to avoid the use of computers. For others who might be interested, the book is cloth bound, has 400 pages, and sells for $60.

K.E. McKee
Director, Engineering Mechanics Division
IIT Research Institute
Chicago, Illinois

SHORT COURSES

APRIL

VIBRATION AND SHOCK SURVIVABILITY, TESTING, MEASUREMENT, ANALYSIS, AND CALIBRATION

Dates: April 6-10, 1981
Place: Boston, Massachusetts
Dates: May 18-22, 1981
Place: Syosset, New York
Dates: August 24-28, 1981
Place: Santa Barbara, California
Dates: October 5-9, 1981
Place: Bournemouth, England

Objective: Topics to be covered are resonance and fragility phenomena, and environmental vibration and shock measurement and analysis; also vibration and shock environmental testing to prove survivability. This course will concentrate upon equipments and techniques, rather than upon mathematics and theory.

Contact: Wayne Tustin, 22 East Los Olivos St., Santa Barbara, CA 93105 - (815) 682-7171.

CORRELATION AND COHERENCE ANALYSIS FOR ACOUSTICS AND VIBRATION PROBLEMS

Dates: April 6-10, 1981
Place: Los Angeles, California

Objective: This course covers the latest practical techniques of correlation and coherence analysis (ordinary, multiple, partial) for solving acoustics and vibration problems in physical systems. Procedures currently being applied to data collected from single, multiple and distributed input/output systems are explained to classify data and systems, measure propagation times, identify source contributions, evaluate and monitor system properties, predict output responses and noise conditions, determine nonlinear and non-stationary effects, and conduct dynamics test programs.

Contact: Department of Engineering and Mathematics, UCLA Extension, P.O. Box 24901, Los Angeles, CA 90024 - (213) 825-4100.

EXPLOSION HAZARDS EVALUATION

Dates: April 6-10, 1981
Place: San Antonio, Texas

Objective: This course covers the full spectrum of problems encountered in assessing the hazards of accidental explosions, in designing the proper containment as necessary, as well as developing techniques to reduce incidence of accidents during normal plant and transport operations. Specific topics to be covered are: fundamentals of combustion and transition to explosion; free-field explosions and their characteristics; loading from blast waves; structural response to blast and non-penetrating impact; fragmentation and missile effects; thermal effects; damage criteria; and design for blast and impact resistance.

Contact: Wilfred E. Baker, Southwest Research Institute, P.O. Drawer 28510, San Antonio, TX 78284 - (512) 684-5111, Ext. 2303.

BASIC INSTRUMENTATION SEMINAR

Dates: April 21-23, 1981
Place: Chicago, Illinois
Dates: April 28-30, 1981
Place: Buffalo, New York
Dates: May 5-7, 1981
Place: Edmonton, Alberta
Dates: September 15-17, 1981
Place: New Orleans, Louisiana
Dates: October 20-22, 1981
Place: Houston, Texas
Dates: October 27-29, 1981
Place: Pittsburgh, Pennsylvania

Objective: This course is designed for maintenance technicians, instrument engineers, and operations personnel - those individuals responsible for installation and proper operation of continuous monitoring systems. An in-depth examination of probe installation techniques and monitoring systems including types, functions, and calibration procedures is provided. Also presented is an overview of some of the instrumentation used to acquire data for vibration analysis, including oscilloscopes, cameras, and specialized filter instruments.

Contact: Kathy Fredekind, Bently-Nevada Corporation, P.O. Box 157, Minden, Nevada 89423 - (702) 782-3611, Ext. 224.

EVALUATION OF TESTING METHODS

Dates: April 29 - May 2, 1981
Place: Gatlinburg, Tennessee
Objective: The objective of this course is to teach laboratory personnel of all industries the fundamentals of collecting, analyzing and interpreting test data. The course addresses itself to the behavior of measurements and presents practical statistical techniques for their proper interpretation. The course is predominately problem oriented. It avoids the cook-book approach and leads rapidly from an understanding of ideas underlying statistical methods to their direct application to practical problems.

Contact: ASQC, Industrial Seminars, c/o R.E. DeBusk, Box 3803, Kingsport, Tennessee 37664 - (615) 245-6793.

MAY

OPTIMIZATION TECHNIQUES

Dates: May 6-9, 1981
Place: Gatlinburg, Tennessee
Objective: The ultimate goal of the industrial experimenter is optimum operating conditions in the laboratory and in the plant. This course will deal with the problem of maximizing product quality while minimizing product cost. The various experimental designs discussed in the course will enable the experimenter to do this both efficiently and economically. Industrial applications with industrial examples will be emphasized throughout the course.

Contact: ASQC, Industrial Seminars, c/o R.E. DeBusk, Box 3803, Kingsport, Tennessee 37664 - (615) 245-6793.

ROTORDYNAMICS OF TURBOMACHINERY

Dates: May 18-20, 1981
Place: College Station, Texas
Objective: To provide a bridge between dynamics theory and the typical hands-on vibrations/instrumentation short course for the engineer who needs a basic understanding of practical turbomachinery rotordynamics. The course will treat balancing, rotordynamic instability, and torsional vibration problems. Fundamentals of each area will be followed up by case histories from engineering practice.

Contact: Dr. John M. Vance, Dept. of Mechanical Engineering, Texas A&M University, College Station, Texas 77843 - (713) 845-1251.

COMPUTER SIMULATION OF HIGH VELOCITY IMPACT

Dates: May 26-28, 1981
Place: Baltimore, Maryland
Objective: Seminar provides an overview of physical response of materials and structures to intense impulsive loading and surveys computer programs for wave propagation and impact studies. Numerous applications are discussed together with guidelines for program selection, implementation and effective use.

Contact: Computational Mechanics Assoc., P.O. Box 11314, Baltimore, Maryland 21239.

JUNE

VIBRATION DAMPING

Dates: June 1-4, 1981
Place: Dayton, Ohio
Objective: The utilization of the vibration damping properties of viscoelastic materials to reduce structural vibration and noise has become well developed and successfully demonstrated in recent years. The course is intended to give the participant an understanding of the principles of vibration damping necessary for the successful application of this technology. Topics included are: damping fundamentals, damping behavior of materials, response measurements of damped systems, layered damping treatments, tuned dampers, finite element techniques, case histories, and problem solving sessions.

Contact: Michael L. Drake, University of Dayton Research Institute, Dayton, Ohio 45469 - (513) 229-2644.

MACHINERY DATA ACQUISITION

Dates: June 1-5, 1981
August 3-7, 1981
September 28 - October 2, 1981
December 7-11, 1981

Place: Carson City, Nevada

Objective: This seminar is designed for people whose function is to acquire machinery data for dynamic analysis, using specialized instrumentation, and/or that person responsible for interpreting and analyzing the data for the purpose of corrective action on machines. Topics include measurement and analysis parameters, basic instrumentation review, data collection and reduction techniques, fundamental rotor behavior, explanation and symptoms of common machinery malfunctions, including demonstrations and case histories. The week also includes a lab workshop day with hands-on operation of the instrumentation and demonstration units by the participants.

Contact: Kathy Fredekind, Bently-Nevada Corporation, P.O. Box 157, Minden, Nevada 89423 - (702) 782-3611, Ext. 224.

MECHANICS OF HEAVY-DUTY TRUCKS AND TRUCK COMBINATIONS

Dates: June 22-26, 1981

Place: Ann Arbor, Michigan

Objective: The heavy truck or truck combination is a complex pneumatic-tired system. This course presents analysis programs, parameter measurement methods and test procedures useful in understanding and designing a vehicle. The course describes the physics of heavy-truck components that determine the braking, steering and riding performance of the total system.

Contact: University of Michigan, College of Engineering, Continuing Engineering Education, 300 Chrysler Center, North Campus, Ann Arbor, Michigan 48109 - (313) 764-8490.

FUNDAMENTALS OF NOISE AND VIBRATION CONTROL

Dates: June 22-26, 1981

Place: Cambridge, Massachusetts

Objective: This one week program is designed to provide a background in those aspects of sound and vibration that are important to noise control engineering. The general approach will be based on engineering concepts rather than theoretical analysis. The program is designed for the working engineer who has become involved in noise problems and seeks to deepen his/her understanding of the subject.

Contact: Director of Summer Session, Room E19-356, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139.

JULY

12th ANNUAL INDUSTRIAL PRODUCT NOISE CONTROL INSTITUTE

Dates: July 6-10, 1981

Place: Schenectady, New York

Objective: For engineers, designers, environmental health specialists and managers concerned with noise and vibration control. This course will provide information on the theory, measurement and economics of noise reduction. It will cover the latest information on the nature of sound and noise control, including noise criteria, airborne sound distribution, vibration control, and noise signature analysis. Other topics include how noise is produced by different types of engineering equipment such as compressors, electric motors, fans, valves, and transformers.

Contact: Union College, Graduate Studies and Continuing Education, Wells House - 1 Union Ave., Schenectady, New York 12308 - (518) 370-6288.

6th ANNUAL APPLIED INSTRUMENTATION AND MEASUREMENTS ENGINEERING

Dates: July 6-10, 1981

Place: Schenectady, New York

Objective: Designed for technicians, engineers and managers involved in the field of instrumentation and measurements. It will present a comprehensive view of the instrumentation system from transducer to readout, including a major emphasis on computer interfacing techniques. Principal topics will include philosophy of measurements, transducer operating principles and selection criteria, static and dynamic data acquisition systems, occurrence and prevention of noise in measurement systems, data reduction methods, digital techniques, and statistical treatment of data. "Hands-on" lab experience will be offered.

Contact: Union College, Graduate Studies and Continuing Education, Wells House - 1 Union Ave., Schenectady, New York 12308 - (518) 370-6288.

INSURANCE INDUSTRY SEMINAR

Dates: July 7-9, 1981
Place: Carson City, Nevada
Objective: This course is designed for personnel from the insurance industry or self-insured companies who are responsible for inspection of plants that use large, high-speed rotating machinery. Features in the seminar include: discussion of the economics of machine monitoring and predictive maintenance; presentation of machine types that should be considered, and minimum standards necessary for effective machine protection diagnosis; information and the presentation of catastrophic failure by use of proper maintenance methods and malfuncion diagnosis techniques; and survey of state-of-the-art methodology.

Contact: Kathy Fredekind, Bently-Nevada Corporation, P.O. Box 157, Minden, Nevada 89423 - (702) 782-3611, Ext. 224.

PLANNING A DIGITAL DATA ACQUISITION AND CONTROL COMPUTER SYSTEM

Dates: July 20-23, 1981
Place: Schenectady, New York
Objective: The course covers the interconnection of a multitude of devices from sensors to final control elements with ultimate output of system conditions on the man-machine interface devices; the sensing of temperature, pressure, level, flow, speed, weight, torque, vibration and electrical parameters such as: volts, amps, watts, vars, power factor, frequency and motor load. The flexibility and utilization of data presentation via dynamic, colored graphic and tabular CRT displays, is presented as an optimum man-machine interface. System components/hardware and their interconnection are discussed in depth. Staging, on-site testing and as-built documentation are the final steps in the planning of a digital acquisition and control computer system.

Contact: Union College, Graduate Studies and Continuing Education, Wells House - 1 Union Ave., Schenectady, New York 12308 - (518) 370-6288.

12th ANNUAL CONFERENCE ON FRACTURE MECHANICS I AND ITS APPLICATION TO FRACTURE CONTROL

Dates: July 20-24, 1981
Place: Schenectady, New York
Objective: Material covered will benefit anyone in an engineering related position who is concerned with the application of fracture mechanics to the prevention of brittle fracture such as pressure vessels for power generation, malleable iron castings, structural steel fabricated frameworks and ASME Pressure Vessel code applications. Included are: engineering approach to component failure; failure analysis of pressure vessels; fracture mechanics based toughness criteria in ASME Pressure Vessel code; examples and case histories of code fracture mechanics applications; elasto-plastic analysis; computer aids for calculating remaining cyclical life; crack initiation and propagation, life prediction, and nondestructive testing methods and capabilities.

Contact: Union College, Graduate Studies and Continuing Education, Wells House - 1 Union Ave., Schenectady, New York 12308 - (518) 370-6288.

COMPUTATIONAL WORKSHOP IN LINEAR AND NONLINEAR STRUCTURAL AND SOLID MECHANICS

Dates: July 27-31, 1981
Place: Schenectady, New York
Objective: For those interested in applications to current technological problems such as earthquake analysis, pipe whip dynamics and fluid-solid interaction, as well as other areas. The following will be covered: structural dynamics techniques for both linear and nonlinear many-degree-of-freedom systems; incremental loading into the plastic range and finite element methods in fracture mechanics; random vibration methods; response spectrum methods for many-degree-of-freedom systems. A nonlinear dynamics computer program as well as eigenvalue and sinusoidal analysis programs will be available for workshop use. Relative merits of ANSYS, SAP, ADINA, etc., programs will be discussed. Computer

graphics for input generation and output presentation will be available.

Contact: Union College, Graduate Studies and Continuing Education, Wells House - 1 Union Ave., Schenectady, New York 12308 - (518) 370-6288.

COMPUTER WORKSHOP IN FINITE ELEMENT METHODS OF ANALYSIS FOR STRESS AND OTHER FIELD PROBLEMS

Dates: July 27-31, 1981

Place: Schenectady, New York

Objective: For those interested in applications to current technological problems such as thermal and stress analysis of nuclear vessel nozzle, 3D pipe intersection, turbine blade application, water mass of nuclear fuel channels, as well as other areas. The following will be covered: finite element techniques for 2D and 3D structural analysis and dynamics; both 2D and 3D programs, including listings; generalization of finite element methods to heat transfer and fluid flow with programs in each discipline; incremental loading into the plastic range and finite element methods in fracture mechanics; relative merits of ANSYS, SAP, ADINA, etc., programs. Computer graphics for input generation and output presentation will be available.

Contact: Union College, Graduate Studies and Continuing Education, Wells House - 1 Union Ave., Schenectady, New York 12308 - (518) 370-6288.

AUGUST

FOUNDATIONS OF ENGINEERING ACOUSTICS

Dates: August 10-21, 1981

Place: Cambridge, Massachusetts

Objective: This summer program is a specially developed course of study which is based on two regular MIT subjects (one graduate level and one undergraduate level) on vibration and sound in the Mechanical Engineering Department. The program emphasizes those parts of acoustics – the vibration of resonators, properties of waves in structures and air – the generation of sound and its propagation that are important in a variety of fields of application. The mathematical procedures that have been found useful in developing the desired equations and their solutions, and the processing of data are also studied. These include complex notation, fourier analysis, separation of variables, the use of special functions, and spectral and correlation analysis.

Contact: Director of Summer Session, Room E19-356, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139.

PYROTECHNICS AND EXPLOSIVES

Dates: August 17-21, 1981

Place: Philadelphia, Pennsylvania

Objective: The seminar combines the highlights of Pyrotechnics and Solid State Chemistry, given the last twelve summers, and Explosives and Explosive Devices that made its successful appearance ten years ago. Similar to previous courses, the seminar will be practical so as to serve those working in the field. Presentation of the theory is restricted to that necessary for an understanding of basic principles and successful application to the field. Coverage emphasizes recent effort, student problems, new techniques, and applications.

Contact: Mr. E.E. Hannum, Registrar, The Franklin Research Center, Philadelphia, Pennsylvania 19103 - (215) 448-1236/1395.

MECHANICAL ENGINEERING

Dates: August 31 - September 4, 1981

Place: Carson City, Nevada

Objective: This course is designed for the mechanical or maintenance engineer who has responsibility for the proper operation and analysis of rotating machinery. Working knowledge of transducers, data acquisition instrumentation and fundamental rotor behavior is a prerequisite. The course includes: a guest speaker in the field of machinery malfunctions; descriptions and demonstrations of machinery malfunctions; discussions of the classification, identification, and correction of various machine malfunctions; a one day rotor dynamics lab with individual instruction and operation of demonstration units; and emphasis on the practical solution of machinery problems rather than rotor dynamic theory.

Contact: Kathy Fredekind, Bently-Nevada Corporation, P.O. Box 157, Minden, Nevada 89423 - (702) 782-3611, Ext. 224.

SEPTEMBER

TENTH ADVANCED NOISE AND VIBRATION COURSE

Dates: September 14-18, 1981

Place: Southampton, England

Objective: The course is aimed at researchers and development engineers in industry and research establishments, and people in other spheres who are associated with noise and vibration problems. The course, which is designed to refresh and cover the latest theories and techniques, initially deals with fundamentals and common ground and then offers a choice of specialist topics. The course comprises over thirty lectures, including the basic subjects of acoustics, random processes, vibration theory, subjective response and aerodynamic noise, which form the central core of the course. In addition, several specialist applied topics are offered, including aircraft noise, road traffic noise, industrial machinery noise, diesel engine noise, process plant noise and environmental noise and planning.

Contact: Mrs. O.G. Hyde, ISVR Conference Secretary, The University, Southampton S09 5NH, England - (0703) 559122 X 2310/752, Telex 47661.

NEWS BRIEFS: news on current and Future Shock and Vibration activities and events

NATIONAL CONFERENCE ON POWER TRANSMISSION
Call for Papers

Papers are being sought by Illinois Institute of Technology for presentation at its 8th National Conference on Power Transmission. The conference will be held October 21, 22, and 23, 1981 at Chicago's McCormick Place in conjunction with the Power Transmission and Fluid Power Show. Frank Eckert, product manager-drives, Koppers Company, Baltimore, Maryland, is director of the 1981 conference, and Dick Dann, staff editor, Machine Design, Cleveland, Ohio, serves as associate director.

Session titles will include the following:

- Electric Motors
- Belts & Couplings
- Gear Boxes
- Clutches & Brakes
- Sleeve Bearings
- Rolling Element Bearings
- Hydrostatic Drives
- Air Bearings
- Programmable Controllers
- Controls

Papers are due June 1, 1981. Abstracts describing proposed papers should be sent as soon as possible.

For further information, contact: Marian Walter, conference secretary, National Conference on Power Transmission, Illinois Institute of Technology, 10 West 32nd Street, Room 232, Chicago, IL 60616 - (312) 567-3636.

ELEVENTH SOUTHEASTERN CONFERENCE ON THEORETICAL AND APPLIED MECHANICS
April 8-9, 1982
Call for Papers

The Eleventh Southeastern Conference on Theoretical and Applied Mechanics will be hosted by the University of Alabama in Huntsville, Huntsville, Alabama. Technical papers will be presented on the results of scientific and engineering research of both applied and theoretical nature in the field of mechanics. The conference will embrace solid mechanics, fluid mechanics, and dynamics as primary fields of interest.

For further information, contact: Dr. C.M. Oliver, Director, Division of Continuing Education, The University of Alabama in Huntsville, Huntsville, AL 35899 - (205) 895-6010.

MECHANICAL FAILURES PREVENTION GROUP 34th SYMPOSIUM
Call for Papers
"Designing for Damage Prevention in the Transportation Environment"

The Mechanical Failures Prevention Group (MFPG), under the sponsorship of the National Bureau of Standards, will hold its 34th Symposium at the National Bureau of Standards, Gaithersburg, Maryland, October 21-23, 1981.

This symposium is seeking papers that will discuss:

- The damage sustained by transported goods during shipment on the ground and in the air arising from the dynamic transportation environment (shock, vibration, temperature, pressure, humidity, etc.)
- Control of the environment through improvements in vehicle and road design, mechanical handling gear, personnel training
- Measurements of the dynamic environment
- Stowing and packaging techniques and design
- Human factors
- Economics - damage prevention and insurance

Proceedings will be published by the National Bureau of Standards. Closing date for abstracts is June 1, 1981.

For further information, contact: Jesse E. Stern, Trident Engineering Associates, 1507 Amherst Road, Hyattsville, MD 20783 - (301) 422-9506; or Dr. J.C. Shang, General American Research Division, General American Transportation Corporation, 7449 North Natchez Avenue, Niles, IL 60648 - (312) 647-9000.

METAL MATRIX COMPOSITES TECHNOLOGY CONFERENCE

The Fourth Metal Matrix Composites Technology Conference, sponsored by the Office of the Undersecretary of Defense for Research in Engineering, will be held at Arlington, Virginia, 19-21 May 1981.

For further information, contact: MMCIAC - Kaman Tempo, P.O. Drawer QQ, Santa Barbara, CA 93012 - (805) 963-6355/6497.

ABSTRACTS FROM THE CURRENT LITERATURE

Copies of articles abstracted in the DIGEST are not available from the SVIC or the Vibration Institute (except those generated by either organization). Inquiries should be directed to library resources. Government reports can be obtained from the National Technical Information Service, Springfield, VA 22151, by citing the AD-, PB-, or N- number. Doctoral dissertations are available from University Microfilms (UM), 313 N. Fir St., Ann Arbor, MI; U.S. Patents from the Commissioner of Patents, Washington, D.C. 20231. Addresses following the authors' names in the citation refer only to the first author. The list of periodicals scanned by this journal is printed in issues 1, 6, and 12.

ABSTRACT CONTENTS

MECHANICAL SYSTEMS

ROTATING MACHINES

(Also see Nos. 846, 857, 864)

81-720

Synthesis of a Torsional Vibration System of a Diesel Engine

T. Nishikawa and T. Ono
Nippon Kokan Kabushiki Kasiha, Tokyo, Japan,
ASME Paper No. 80-DGP-12

Key Words: Shafts (machine elements), Diesel engines, Torsional vibration, Tuned frequencies

A method of systematic detuning of a lumped-mass vibration system is proposed and its application to a diesel engine shafting system is shown. Influence number of a system parameter is derived through partial derivative of the residual torque of Holzer's method. The influence number and non-dimensional modification of a system parameter permits simple detuning of the system using a graphical method.

81-721

Influence of Unequal Pedestal Stiffness on the Instability Regions of a Rotating Asymmetric Shaft (2nd Report, Inclinational Vibrations with Effects of Gyroscopic Action)

H. Ota, K. Mizutani, and M. Miwa
Faculty of Engrg., Nagoya Univ., Chikusa-ku, Nagoya, Japan,
Bull. JSME, 23 (183), pp 1514-1521 (Sept 1980) 7 figs, 4 refs

Key Words: Shafts (machine elements), Gyroscopic effects, Supports

The gyroscopic action of a rotor tends to split up the unstable regions which result mainly from the asymmetry of shaft stiffness into several parts by the inequality of bearing stiffness. The analysis of this problem is carried out on the assumption that the coefficient of gyroscopic term is as small as bearing stiffness and asymmetry of shaft stiffness, or is larger than both bearing stiffness and asymmetry of shaft stiffness. The position, width and number of unstable regions are analytically determined.

81-722

Prediction of Dynamic Properties of Rotor Supported by Hydrodynamic Bearings Using the Finite Element Method

Y. Birembaut and J. Peigney
CETIM, Centre Technique des Industries Mecaniques, Senlis, France,
Computers Struc., 12 (4), pp 483-496 (Oct 1980) 18 figs, 1 table, 11 refs

Key Words: Rotor-bearing systems, Finite element technique, Computer programs, Critical speeds, Unbalanced mass response

The purpose of this paper is to present general programs for rotor bearing analysis using the finite element method. A consistent representation of both mass and stiffness is used for the rotor shaft, while hydrodynamic bearings are calculated by solving Reynolds equation. Dynamic characteristics of these bearings are then obtained with a perturbation method. These programs are first compared with both numerical and experimental results from literature. The influence of bearing characteristics on stability threshold and unbalance response of a rotor is studied.

81-723

Non-Linear Dynamics of Flexible Multi-Bearing Rotors

M.L. Adams
Dept. of Mechanical Engrg., University of Akron, Akron, OH 44325,
J. Sound Vib., 71 (1), pp 129-144 (July 8, 1980) 6 refs, 11 figs

Key Words: Rotors (machine elements), Flexible rotors, Periodic excitation, Transient excitation, Rotor-bearing systems

A general analysis has been developed to simulate steady state and transient vibration phenomena of complex rotor-bearing-support systems on the computer. A central feature of this analysis is a proper handling of various highly non-linear effects (most notably journal bearings) which dominate the dynamic phenomena encountered during large amplitude rotor-bearing vibrations. There are a number of potential causes of large amplitude rotor vibration, such as high rotor imbalance (e.g., loss of turbine blades at running speed), critical speed operation, journal bearing dynamic instability (oil whip), earthquakes, and shock. Failure mode analysis requires the evaluation and understanding of such potentially large dynamic forces and displacements. The paper presents development of the analysis, comparison with experiment and examples of its use in industrial applications.

81-724
Experiments of the Vibration Characteristics of the Rotor with Flexible, Damped Support
Y.L. Tong and L.Q. Han
Beiying Aeronautical Inst., Beiying, Peoples Rep. of China, ASME Paper No. 80-GT-124

Key Words: Rotors (machine elements), Flexible foundations, Damping effects

Experiments were conducted on a model rotor test rig with a disk located at the mid span and a squeeze film damper and/or flexible support at one end and a rigid support at the other end. The damping effects of the flexible support and stress variation of the support itself were tested. Emphasis was placed on the steady-state characteristics and the damping effects of the flexible supports and dampers with different radial clearances under various level of rotor unbalance.

81-725
Rotordynamic Instability in Centrifugal Compressors - Are All the Excitations Understood?
J.M. Vance and F.J. Laudadio
Texas A&M Univ., College Station, TX, ASME Paper No. 80-GT-149

Key Words: Compressors, Stability, Stiffness coefficients, Damping coefficients

A published history of rotordynamic instability problems with centrifugal compressors is documented from the literature. Established theory for computerized stability analysis is reviewed, and the use of cross-coupled stiffness and damping coefficients to represent destabilizing forces is explained. A derivation of cross-coupled stiffness coefficients for torquewhirl is presented. Experimental measurements made on a simple test rig with a radial vaned impeller are described.

81-726
The Effect of Aerodynamic Phase Lag on the Twin Vibration Mode Model of Aeroengine Fan Flutter
R.A.J. Ford
Univ. of New South Wales, New South Wales, Australia, ASME Paper No. 80-GT-166

Key Words: Fans, Flutter

This paper extends the analysis of aeroengine fan flutter by incorporating variable aerodynamic phase lags between a blade motion and the resulting aerodynamic forces. The extended analysis predicts two independent kinds of flutter.

81-727
Aerodynamic Analysis of a Supersonic Cascade Vibrating in a Complex Mode
J.E. Caruthers and R.E. Riffel
The Univ. of Tennessee Space Inst., Tullahoma, TN 37388, J. Sound Vib., 71 (2), pp 171-183, 10 refs, 12 figs, 1 table

Key Words: Fans, Compressors, Harmonic excitation

An analysis is presented which has been used to predict the unsteady aerodynamic behavior of a finite supersonic cascade of airfoils forced in harmonic oscillation with airfoil-to-airfoil variations in amplitude. Theoretical predictions are compared with some recent experimental results at a reduced frequency representative of actual fan or compressor flutter cases. The similarity of the experimental situation in the finite cascade to the flutter of a severely mistuned rotor is noted.

METAL WORKING AND FORMING
(See No. 756)

STRUCTURAL SYSTEMS

BRIDGES

81-728
On Stochastic Dynamics of Floating Bridges
I. Langen and R. Sigbjornsson
The Norwegian Inst. of Tech., Trondheim, Norway, Engrg. Struc., 2 (4), pp 209-216 (Oct 1980) 4 figs, 2 tables, 23 refs

Key Words: Bridges, Pontoon bridges, Stochastic processes, Water waves

A theoretical analysis of the dynamic behavior of floating bridges is presented. The main emphasis is placed on the

wave-induced response. The structural idealization is based on the finite element technique. Alternative solution techniques of the equations of motion are discussed, including a sample treatment based on Monte Carlo simulation of time-space realizations of the wave loading processes combined with step-by-step integration. Results from numerical analysis of a continuous curved floating bridge are presented. This includes a demonstration of the influences of the shortcrestedness of waves on the structural response.

81-729
Wind Induced Dynamic Response of the Wye Bridge
I.J. Smith
Bridge Design Div., Structures Dept., Transport and Road Res. Lab., Crowthorne, Berks, UK, Engrg. Struc., 2 (4), pp 202-208 (Oct 1980) 11 figs, 2 tables, 10 refs

Key Words: Bridges, Wind-induced excitation, Wind tunnel tests

As part of the research effort to improve the understanding of the effect of wind on bridges, the wind-induced dynamic response of the 235 m span cable stayed box girder bridge was measured. Measurements are presented which were made during the winter months of 1977 and 1978, using automatic recording equipment. The effect on the fatigue life of the structure is discussed. It is shown that it is most unlikely that wind-induced oscillations will contribute to a significant shortening of the fatigue life of the bridge.

81-730
Finite Element Analysis of Suspension Bridges
S.G. Arzoumanidis
Ph.D. Thesis, Columbia Univ., 95 pp (1980)
UM 8023472

Key Words: Suspension bridges, Finite element technique, Moving loads, Wind-induced excitation

A finite element analysis of the nonlinear response of suspension bridges subjected to static and dynamic loads is reported. Geometric nonlinearities of the cable and deck elements as well as nonlinear stress-strain relations of elasto-plastic type have been taken into account. The problems analyzed contain the determination of static positions of equilibrium of a bridge subjected to aero-dynamic forces of steady wind, the dynamic response of a bridge subjected to moving loads, simulation of the motion of a bridge subjected to buffeting and self-excited wind forces. Criteria of static and dynamic instability of bridges under wind loading have been formulated.

BUILDINGS

(Also see Nos. 820, 830)

81-731
Earthquake Floor Response and Fatigue of Equipment in Multi-Storey Structures
J.C. Wilson
Dept. of Civil Engrg. and Engrg. Mechanics, McMaster Univ., Hamilton, Canada, Engrg. Struc., 2 (4), pp 253-258 (Oct 1980) 6 figs, 1 table, 11 refs

Key Words: Buildings, Multistory buildings, Earthquake response, Equipment response

Recent earthquakes such as 1971 San Fernando have drawn attention to the behavior of equipment services within multi-storey structures, most notably as a result of the failure of some of these installations during moderate seismic activity. Of major concern are telephone switching centres, electrical switchgear stations, hospitals and similar utilities and public services. This paper examines the seismic response of multi-storey structures and their equipment installations and attempts to characterize some parameters of equipment response which prove useful in laboratory dynamic testing. Mathematical models of several typical structures are subjected to a 30 s earthquake excitation and the seismic response at the top floor of each building is evaluated.

FOUNDATIONS

81-732
Dynamic Response of Pile-Supported Frame Foundations
F. Aboul-Ella and M. Novak
College of Architecture, King Faisal Univ., Dammam, Saudi Arabia, ASCE J. Engr. Mech. Div., 106 (EM6), pp 1215-1232 (Dec 1980) 10 figs, 2 tables, 24 refs

Key Words: Pile foundations, Turbomachinery, Rotor-induced vibration, Unbalanced mass response, Interaction: soil-structure, Substructuring methods, Dynamic stiffness, Finite element technique

A theoretical approach is analyzed of the dynamic response of pile-supported frame foundations of turbomachineries to rotor unbalances. The approach includes dynamic interaction of soil, piles, flexible foundation mat, three-dimensional structural frame, flexible rotor, and viscoelastic oil film in journal bearings. The approach employs substructuring, dynamic stiffness method, and finite elements. Shear deformations and material damping are included in the stiffness matrices of the finite elements that are complex and frequency dependent. The stiffness matrix of the element is generalized to incorporate the stiffness and damping of the supporting medium including piles. It was found that soil-structure interaction markedly affects the response of the frame as well as the rotors in the lowest resonant regions. In the vicinity of a high operating speed, soil-structure interaction can be neglected.

81-733

Dynamic Response and Liquefaction of Earth Structures

T.A. Mansouri

Ph.D. Thesis, Colorado State Univ., 201 pp (1980) UM 8022412

Key Words: Soils, Liquefaction, Wave propagation, Elastic waves

The dynamic response of earth structures has been under study for many years. Several procedures have been developed to predict their behavior and thus enable engineers to make better designs. Among these procedures are mathematical models that can simulate their dynamic response. In the study included in this thesis, a numerical model that can simulate this behavior which also takes the liquefaction phenomenon into account is developed. The model is based on Biot's theory of propagation of elastic waves in a fluid saturated porous solid. It also takes into consideration the fact that saturated soils tend to compact under dynamic loading and thus liquefy. The developed model couples Biot's theory with Finn's empirical relation for the increase in pore water pressure to predict liquefaction. To verify the model an analytical solution for the propagation of pressure waves in a one dimensional space is formulated. The results of the model compare extremely well with the analytical ones. Finally the dynamic behavior and liquefaction of an ideal earth dam is studied.

POWER PLANTS

(Also see Nos. 763, 764, 802, 862)

81-734

The Effect of Reactor Coolant System Rupture Motion on Tributary Piping and Attached Equipment

R.P. Kassawara, S.C. Austin, and R.C. Izor

Combustion Engrg. Inc., Windsor, CT, ASME Paper No. 80-C2/PVP-24

Key Words: Nuclear reactor safety, Nuclear reactor components, Cooling systems

This paper presents a rigorous analysis of a pressurized water reactor coolant system (RCS) to determine time-history excitations of intact equipment and tributary piping attached to the RCS caused by a postulated guillotine rupture in the primary coolant piping. Reactor control rods and drive mechanisms, in core instrumentation guide tubes and reactor coolant pump motor appurtenances are examples of attached equipment that is excited by RCS LOCA induced motions. The methods described herein include structural and dynamic modeling and analytical techniques used in the nonlinear transient dynamic time-history analysis of a 3-D coupled model of the RCS.

81-735

Application of the Spectral Method to Estimate the Structural Reliability of a Reactor Containment

J. Bauer and H.S. Choi

Research Associates, Technische Universität München, W. Germany, Computers Struc., 12 (4), pp 421-426 (Oct 1980) 3 figs, 18 refs

Key Words: Nuclear power plants, Seismic design, Nuclear reactor containment, Containment structures, Damage prediction, Probability theory

In this paper structural reliability is studied for the secondary containment of a nuclear power plant subjected to ground motions during an earthquake. The occurrence of earthquakes is modeled by a filtered Poisson process and the ground motion by a stationary normal process. Within linear-elastic material behavior the structural response is evaluated in terms of power spectral density. Hereby the interaction between soil and structure is taken into account.

81-736

Fluid-Structure Interaction: A General Method Used in the CEASEMT Computer Programs

A. Combescure, R.J. Gibert, F. Jeanpierre, A. Hoffmann, and M. Livolant

Centre d'Etudes Nucleaires de Saclay, 91190-Gif-sur-Yvette, France, Computers Struc., 12 (4), pp 471-474 (Oct 1980) 3 figs, 12 refs

Key Words: Interaction: structure-fluid, Fluid-induced excitation, Nuclear reactor components, Seismic excitation, Finite element technique, Computer programs

This paper presents a general method to calculate the dynamic behavior of coupled fluid-structure systems. It is shown how this method can be easily implemented in finite element computer codes. Some applications in the case of axisymmetric and three dimensional structures are compared either with analytical or with experimental results. A reference is given for fluid-structure interaction in piping systems.

81-737

Operability Assurance Testing of ASME Code, Class 1, Safety/Relief Valves

L.E. Frazier, B.G. Fowler, and J.J. Boseman

Wyle Lab., Huntsville, AL, ASME Paper No. 80-C2/PVP-29

Key Words: Standards and codes, Valves, Seismic excitation, Nuclear power plants

The paper describes the testing performed on an Active ASME Code Class 1 Safety/Relief Valve (SRV) to satisfy the intent of the operability requirements of Nuclear Regulatory Guide 1.48. The purpose of the test was to demonstrate SRV operability and structural integrity when subjected to static piping loads, dynamic seismic loads and in-service temperature and pressure, which may be imposed on the SRV while installed in a nuclear power plant.

81-738

A Critical Review of Risk and Reliability Concepts as Used to Mitigate Earthquake Effects on Power Systems

A.J. Schiff

Purdue Univ., West Lafayette, IN, ASME Paper No. 80-C2/PVP-40

Key Words: Electric power plants, Earthquake resistant structures

While the concepts of reliability have been used in power system networks for decades, these methods generally have not been used to mitigate earthquake and other hazards to equipment. The current uses of risk, reliability and cost-benefit analysis as applied to the earthquake problems are reviewed. Some of the reasons impeding the application of these methods to power equipment are considered.

OFF-SHORE STRUCTURES

81-739

Response of Fixed Offshore Structures in Random Sea

D.C. Angelides and J.J. Connor

Res. and Dev. Div., McDermott Inc., New Orleans, LA, Intl. J. Earthquake Engr. Struc. Dynam., 8 (6), pp 503-526 (Nov/Dec 1980) 14 figs, 22 refs

Key Words: Offshore structures, Water waves, Random excitation

An integrated model is developed for the short-term and long-term dynamic response of an offshore structure subjected to random wave excitation. A discrete linear, elastic model of the upper structure is coupled with an iterative linear quasi-three-dimensional finite element model for the pile-soil medium, and the system is subjected to stochastic storms described by mean rate of arrival, joint probability distribution of storm duration and average intensity, and a random process that describes the variations of a statistical wave height measure during each storm.

81-740

Analyses of In-Line Flow-Induced Vibrations Using Linearization Methods

T. Chen

Ph.D. Thesis, The Univ. of Texas at Austin, 199 pp (1980)

UM 8021413

Key Words: Fluid-induced vibration, Equivalent linearization method, Marine risers

In-line flow-induced vibrations of structures are investigated in this study. A simplified single-degree-of-freedom system is considered first. Then a discrete multi-degree-of-freedom system is examined. This system is used to predict the response of marine riser systems used in offshore drilling operations. The reliability and efficiency of the presented approaches are examined by comparing their results with the "exact" solutions obtained by direct integration of the nonlinear equation of motion. A variety of parameter studies are presented. Particular emphasis is given to the dependence of important design parameters of the riser system on several environmental variables.

VEHICLE SYSTEMS

GROUND VEHICLES

(Also see No. 754)

81-741

Processing of Dynamic Truck Weighing Signals (Verarbeitung dynamischer Wiegesignale von Lastkraftwagen)

U. Schreiber and A. Schröder
Philips GmbH Forschungslaboratorium Hamburg, Vogt-Kolln-Str. 30, 2000 Hamburg 54, West Germany, Techn. Messen-ATM, 6 (47), pp 219-222 (June 1980) 5 figs, 10 refs
(In German)

Key Words: Trucks, Dynamic weighing method

Dynamic weighing of trucks makes it possible to determine their weight during the transit over a fixed weighing platform. The weight signal contains besides a static component representing the load some dynamic parts, mainly caused by vibrations of the truck and the weighing bridge. Two methods for processing the dynamic weight signals on the basis of mathematical models are described and some results are presented and discussed.

81-742

Stability Criteria for Automobile-Trailer Combinations

E.C. Mikulcik
The Univ. of Calgary, Calgary, Alta, Canada T2N 1N4, Vehicle Syst. Dyn., 9 (5), pp 281-289 (Sept 1980) 4 figs, 1 table, 11 refs

Key Words: Automobiles, Trailers, Articulated vehicles, Stability

The characteristic equation for a simple automobile-trailer combination is analyzed, revealing the parameter groups which are important in determining the stability characteristics. Application of Routh's method results in separate criteria for oscillatory and non-oscillatory criteria which can be evaluated algebraically, and which can also be displayed graphically showing a region of stability on a two-dimensional plot. The stability region is bounded by limits of oscillatory and non-oscillatory stability, and the evaluation of a specific case corresponds to the location of a point relative to the boundaries.

81-743

The Trailer Swinging Problem - A Phase Plane Analysis

M. Singh
Stevens Inst. of Tech., Hoboken, NJ, ASME Paper No. 79-WA/DSC-13

Key Words: Articulated vehicles, Tractors, Trailers, Dynamic response

A tractor-semitrailer model, in which the tractor remains in equilibrium while the trailer is swinging, is considered. The linearized system equations yield a critical forward speed, above which the equilibrium state is a stable focus otherwise a stable node. A phase-portrait is drawn using the nonlinear system equations, which shows a stable focal point and two saddle points. A brief discussion follows illustrating the effects of impulsive perturbations and multi-step inputs on the system dynamics.

81-744

A Theoretical Analysis of the Ride Vibration of Agricultural Tractor and Trailer Combinations

D.A. Crolla
Dept. of Mech. Engrg., Univ. of Leeds, Leeds LS2 9JT, Vehicle Syst. Dyn., 9 (5), pp 237-260 (Sept 1980) 12 figs, 3 tables, 15 refs

Key Words: Tractors, Trailers, Agricultural machinery, Vibration response

A six degree of freedom model of an agricultural tractor and trailer combination has been developed. Results from eigenvalue and frequency response calculations indicated that tractor operator vibration levels will be higher when operating with a trailer than for the tractor alone, due mainly to increased tractor pitch motion. Although minor improvements could be made to present tractor and trailer combinations by moving the hitch forward of the tractor rear axle or providing some damping at a sprung hitch, the scope for a significant improvement in ride lies in changing the configuration. If higher speed specialized transport vehicles prove economical for agriculture, there are some advantages in ride vibration to be gained by changing the layout of the tractor and trailer combination to resemble an off-road version of a commercial articulated lorry.

81-745

Ride Vibration Measurements of Agricultural Tractor and Trailer Combinations

D.A. Crolla and A.K. Dale
Dept. of Mech. Engrg., Univ. of Leeds, Leeds LS2 9JT, Vehicle Syst. Dyn., 9 (5), pp 261-279 (Sept 1980) 11 figs, 1 table, 35 refs

Key Words: Tractors, Trailers, Agricultural machinery, Vibration measurement

Tractor ride vibration levels have been measured when operating with and without a two wheel unbalanced and a four wheel balanced trailer. Measurements were made in the vertical, pitch, longitudinal and roll directions with the trailers unladen and laden over four typical farm surfaces. The results showed that tractor ride vibration levels were usually increased in all directions.

81-746
Analysis and Measurement of Locomotive Dynamic Characteristics
P. Tong, R. Brantman, and R. Greif
Transportation Systems Ctr., Cambridge, MA, ASME Paper No. 79-WA/RT-10

Key Words: Locomotives, Dynamic properties

In June of 1977, comparative tests of the E-8 and SDP-40F locomotives were conducted on Chessie System track with the goal of comparing dynamic performance of these locomotives and identifying key track, vehicle, and operational parameters affecting safety. Based on the test results, it was possible to establish that significant differences existed in the response of these two locomotives when operating in curves above the balance speed. The test data also enabled quantification of the influence of variations in truck vertical damping, lateral axle clearance, and wheel diameter mismatch.

81-747
Two-Dimensional Dynamics of Tracked Ram Air Cushion Vehicles with Fixed and Variable Winglets
L.M. Sweet, H.C. Curtiss, Jr., and R.A. Luhrs
Princeton Univ., Princeton, NJ, ASME Paper No. 79-WA/DSC-11

Key Words: Ground effect machines, Tracked vehicles, Guideways, Ride dynamics

A linearized model of pitch-heave dynamics of a Tracked Ram Air Cushion Vehicle is presented. This model is based on aerodynamic theory which has been verified by wind tunnel and towed model experiments. The ride quality and dynamic motions of the fixed winglet vehicle moving at 330 km/h over a guideway described by roughness characteristics typical of highways is examined in terms of the rms values of vertical acceleration in the foremost and rearmost seats in the passenger cabin and gap variations at the leading and trailing edges of the vehicle.

81-748
Validation and Verification of Rail-Vehicle Models
T.K. Hasselman and L. Johnson
J.H. Wiggins Co., Redondo Beach, CA, ASME Paper No. 79-WA/DSC-8

Key Words: Interaction: rail-vehicle, Mathematical models

A conceptual approach to model validation and verification is developed for application to rail-vehicle systems. In this paper, validation and verification are distinguished, respectively, by association with the qualitative (structure definition) and quantitative (parameter estimation) aspects of the modeling problem.

SHIPS

(Also see No. 863)

81-749
Investigation of the Containership Vibration Behaviour by Finite Element Method at Design Stage
C. Camisetti, A. Macco, and G. Polidorou
CETENA s.p.a. (Italian Ship Res. Centre), Genova, Italy, Computers Struc., 12 (4), pp 395-407 (Oct 1980) 10 figs, 5 tables, 5 refs

Key Words: Ship vibration, Containers, Design techniques, Mathematical models, Finite element technique

The aim of this paper is to study at design stage the vibratory behavior of the main substructures of containerships. Two different ships of 16400 and 25000 DWT with non-similar structural features are investigated. A quite different modeling is used to generate the three-dimensional finite element meshes. Compliance analysis is performed. The response amplitude, for any frequency in the range investigated, is analyzed at a set of given joints, and resonant peaks and mean levels of response are found and compared with exciter test results. A sensitivity analysis is also carried out through examination of the parameters affecting the phenomenon: structural model, added mass and damping.

81-750

Modelling Aspects for Finite Element Analysis of Ship Vibration

K.T. Skaar and C.A. Carlsen
Det norske Veritas, Oslo, Norway, Computers Struc., 12 (4), pp 409-419 (Oct 1980) 19 figs, 1 table, 17 refs

Key Words: Ship vibration, Design techniques, Mathematical models, Finite element technique

The paper describes the present state-of-the-art in analyses of ship vibration and elaborates on the difficulties regarding the finite element modeling. Some suggestions to enable better modeling of the structure, dependent on the aims of the analyses, the accuracy of input data, time and cost are given. It is shown that the main resonant frequencies of global and local structures may be predicted with sufficient accuracy, and a good indication of the forced response level may be obtained at the design stage.

AIRCRAFT

81-751

Crash Tests of Four Identical High-Wing Single-Engine Airplanes

V.L. Vaughan, Jr. and R.J. Hayduk
NASA Langley Res. Ctr., Hampton, VA, Rept. No. NASA-TP-1699; L-13076, 70 pp (Aug 1980)
N80-30296

Key Words: Crash research (aircraft)

Four identical four place, high wing, single engine airplane specimens with nominal masses of 1043 kg were crash tested at the Langley Impact Dynamics Research Facility under controlled free flight conditions. These tests were conducted with nominal velocities of 25 m/sec along the flight path angles, ground contact pitch angles, and roll angles. Three of the airplane specimens were crashed on a concrete surface; one was crashed on soil. Crash tests revealed that on a hard landing, the main landing gear absorbed about twice the energy for which the gear was designed but sprang back, tending to tip the airplane up to its nose. On concrete surfaces, the airplane impacted and remained in the impact attitude. On soil, the airplane flipped over on its back. The crash impact on the nose of the airplane, whether on soil or concrete, caused massive structural crushing of the forward fuselage.

81-752

Calculation of Critical Flutter Speeds of an Aircraft in Subsonic Flow

N.L. Maričić
Vazduhoplovnotehnicki institut-Zarkovo, Niska b.b., 11132 Zarkovo, Yugoslavia, Computers Struc., 12 (4), pp 475-482 (Oct 1980) 1 fig, 4 tables, 13 refs

Key Words: Aircraft, Flutter, Minicomputers

The procedure for calculation of critical flutter speeds of an aircraft in subsonic flow on minicomputer, is displayed in the paper. Problem of vibrational asymmetry, determined during vibrational tests, is solved using decomposition of each mode into inertially normalized symmetrical and antisymmetrical parts. Unsteady aerodynamic loadings are determined by the doublet-lattice method. Modest memory of minicomputer used dictated the choice of the method of optimal elimination for solution of an asymmetric system of complex linear equations. Interpolation of total matrices of generalized aerodynamical forces is done by, in this paper proposed, modified method of natural cubic spline. Flutter eigenvalues are calculated using iterative Laguerre's procedure.

81-753

Airframe Noise Measurements on a Supersonic Transport Small-Scale Model

J.S. Preisser
NASA Langley Res. Ctr., Hampton, VA, J. Aircraft, 17 (11), pp 795-801 (Nov 1980) 14 figs, 3 tables, 15 refs

Key Words: Aircraft noise, Noise measurement

Airframe noise has been measured on a 0.015 scale model of an advanced supersonic transport concept (AST-100) in an anechoic flow facility. The model was equipped with leading- and trailing-edge flaps, nose and main landing gears, and engine nacelles. Each of these components was deployed, individually and collectively, to determine their contribution to the noise field. Results are presented which show that in the clean configuration the aircraft displays a symmetric dipole directivity, whereas in the more complex landing-approach configuration the directivity peaks in the forward quadrant. It was found that the landing-approach noise was due chiefly to the landing gear, the trailing-edge flaps, and the aeroacoustic interaction between the two.

MISSILES AND SPACECRAFT

(See No. 858)

BIOLOGICAL SYSTEMS

HUMAN

(Also see No. 861)

81-754

Wind Noise Exposure of Motorcycle Riders

K. Satsangi and A.S. Howell
Bombardier, Inc., Montreal, Canada, ASME Paper No. 79-WA/SAF-1

Key Words: Motorcycles, Aerodynamic noise, Wind tunnel tests, Human response

This study deals with the measurement of at-ear aerodynamic noise levels for various flow speeds in a wind tunnel, with a full-scale human head model. These results are compared to the total noise levels obtained by live subjects in typical highway driving under similar conditions.

81-756

Theoretical Analysis of Self-Excited Vibrations in a Machine-Tool, Isolated Mounting-Base System

F. Soavi
Istituto di Progetti di Macchine e Tecnologie Meccaniche, Facolta di Ingegneria, Universita di Bologna, Italy, Meccanica, 15 (1), pp 54-69 (Mar 1980) 8 figs, 3 refs

Key Words: Machine tools, Mountings, Isolators

This paper describes the theoretical analysis of the dynamic performance of a machine-tool isolated mounting-base system when unstable behaviour of the moving slider -- stick slip motion – occurs owing to low driving speed. The equations of motion are derived from Lagrange's equation when the basic energy expressions of such a system are known. Numerical examples are calculated by making use of the digital computer in order to clarify the relation between the principal parameters governing the behavior of the vibrating system so that the factors that influence the design and operational conditions of a machine tool supported by a vibration-isolating base may be more clearly understood and specifically identified. By this method a detailed analysis is carried out of the performance of an experimental rig fixed to a concrete mounting base supported on helical springs, in order to investigate the mechanism of frictional damping of machine tool slideways.

MECHANICAL COMPONENTS

ABSORBERS AND ISOLATORS

81-755

Design Considerations for Application of Metallic Honeycomb as an Energy Absorber

W.H. Lee and R.E. Roemer
Tennessee Valley Authority, Knoxville, TN, ASME Paper No. 80-C2/PVP-57

Key Words: Energy absorption, Honeycomb structures

This paper presents the results of static and dynamic crush tests concerned with the effect of impact velocity, material properties, cell density, loading configuration, and overall pad geometry. Specific design recommendations are made in each area, and suggestions are provided to improve fabrication techniques and minimize subsequent problems.

81-757

A Methodology for Modeling Confined, Temperature Sensitive Cushioning Systems

V.P. Kobler
Ground Equipment and Missile Structures Directorate, Army Missile Command Redstone Arsenal, AL, Rept. No. DRSMI/RL 80-10, AD-E950 004, 164 pp (June 1980)
AD-A087 351/3

Key Words: Packaging materials, Impact response (mechanical), Model testing, Testing techniques

A methodology for modeling the impact response of a confined cushioning system has been demonstrated. Data for modeling were acquired from test drops made with a test specimen comprised of a plywood cube (protected item) within a cleated plywood shipping container, under controlled environmenal conditions, utilizing 2-inch Minicel as the cushioning system. Individual curves were developed for each temperature and drop height for both the interior box and total container system. Utilizing a stepwise regression procedure, a general model was developed for the interior box and also for the total container system. The general model permits the cushion designer to predict the impact response of a container system with drop heights of 12 to 30 inches, a temperature range of −65 F to 160 F, and a static stress range of 0.088 to 1.255 psi.

TIRES AND WHEELS

81-758

A Mathematical Model of the Rolling Pneumatic Tire under Load

M. Loo

Ph.D. Thesis, The Univ. of Michigan, 150 pp (1980)
UM 8025719

Key Words: Pneumatic tires, Mathematical models, Rolling friction

A mathematical model of a structural analog of the pneumatic tire is developed. The model is concerned with the prediction of the vertical load-deflection characteristics of a standing or rolling tire on a flat or cylindrical surface and the prediction of the tire's free rolling resistance. Experimental verification of the model's performance characteristics was conducted on three similar size tires of different carcass constructions; namely, the bias-ply tire, the bias-belted tire and the radial tire. Results for the tire's vertical load-deflection characteristics show close correlation between predicted and experimental values for a wide range of tire inflation pressures. The present work demonstrates the use of a simplified model in describing the performance characteristics of the pneumatic tire in vertical loading and straight-line free rolling. In particular, the model enables one to define a pneumatic tire's vertical stiffness characteristics with relatively few parameters, thus circumventing the necessity of knowing the complete stress-strain state of the entire tire structure. The same parameters also yield useful estimates of the distribution of normal forces within the tire's contact region with the road surface and the tire's cold rolling resistance characteristics.

BLADES

(Also see Nos. 855, 865)

81-759

Dynamic Cascade Facility and Methods for Investigating Flow-Excited Vibration and Aerodynamic Damping of Model Low Pressure Blade Groups

Z. Kovats

Westinghouse Electric Corp., Pittsburgh, PA, ASME Paper No. 79-WA/GT-6

Key Words: Turbine blades, Fluid-induced excitation, Flutter, Aerodynamic damping

A dynamic cascade facility for investigating the flutter and aerodynamic damping of low pressure turbine blade groups vibrating in the first three modes is described. Two methods were used for measuring the positive or negative aerodynamic damping. The power flow method yields the fundamental sinusoidal component of the total aerodynamic force on the blade group that is in phase with the vibration velocity, and the interferometric method yields the instantaneous aerodynamic force of a blade versus time during a vibration cycle. The aerodynamic damping measured by both methods is shown for a model blade group vibrating in the twist-mode.

BEARINGS

81-760

A Finite Element Non-Linear Stability Analysis for Journal Bearings

G. Manfrida and F. Martelli

Dept. of Energetics, Univ. of Florence, Italy, Meccanica, 15 (1), pp 47-53 (Mar 1980) 12 figs, 10 refs

Key Words: Bearings, Journal bearings, Finite element technique

A finite element approach to the problem of stability of horizontal journal bearings is presented and compared with an alternative well-known approximate method. Reynolds' equation for laminar incompressible flow is numerically integrated, with no theoretical limits due to particular bearing geometries. This allows the extension of results to most commonly encountered industrial designs. Particular care is devoted to the computer optimization of the problem. The result is a program suitable for storage in small computers and for bearing industrial design.

81-761

Effect of Surface Ellipticity on Dynamically Loaded Spherical and Cylindrical Joints and Bearings

P.K. Goenka

Ph.D. Thesis, Cornell Univ., 1933 pp (1980)
UM 8020823

Key Words: Spherical bearings, Fluid-film bearings, Joints (junctions), Geometric effects

The finite element formulation for regular spherical and cylindrical bearings is extended to include irregular (nonspherical and non-cylindrical) bearing surfaces as well. The formulation is limited to planar loads and displacements. The optimum bearing shape for a cylindrical bearing is sought for a specific duty cycle with a constant load and sinusoidal angular displacement. The optimization is done with a view to maximizing the minimum film thickness. The optimum shape (found only among elliptical irregularities) for a one-dimensional cylindrical bearing is found to have a circular journal and an elliptical sleeve (with a particular ellipticity). For this optimum bearing the absolute minimum film thickness is about a factor of 36 higher as compared to the regular (cylindrical) bearing. The absolute maximum pressure for this optimum bearing is about a factor of 5 lower than that for the regular bearing. A similar performance improvement was found for an irregular spherical bearing over a regular spherical bearing. For both spherical and cylindrical bearings some example problems were solved with forces and angular displacements found in hip joints as duty data.

GEARS

81-762

Vibrational Excitation of Cylindrical Involute Gears Due to Tooth Form Error

A. Kubo and S. Kiyono
Kyoto Univ., Dept. Prec. Mech., 606 Kyoto, Japan,
Bull. JSME, 23 (183), pp 1536-1543 (Sept 1980) 12 figs, 2 tables, 8 refs

Key Words: Helical gears, Gear teeth, Initial deformation effects, Vibration response

A method is shown to estimate the degree of vibrational excitation of involute helical gears due to transverse and longitudinal tooth form errors and periodical change of tooth stiffness with progress of meshing. Some charts and a table are shown to give results of this analysis for the combinations of four gear pairs of different dimensions and four different kinds of tooth form errors.

VALVES

81-763

Fundamental Frequency of a Nuclear Valve Upperstructure - Theory and Experiment

B.L. Patel, T.W. Lancey, and V. Nagpal
Bechtel Power Corp., Norwalk, CA, ASME Paper No. 79-WA/PVP-2

Key Words: Valves, Nuclear reactor components, Fundamental frequencies, Rayleigh method

Theory is developed for the hand calculation of the fundamental frequency of a nuclear valve upperstructure, using Rayleigh's principle. Modeled as a multiple degree of freedom cantilever, the system is divided into three components: the yoke and operator, which are treated as elastic members, and the manual override, treated as a lumped mass. The valve upperstructure is subjected to dynamic testing which yields instantaneous values of yoke acceleration and power spectral density. Hand calculation results agree with those of the finite element program and the experiment. Therefore, the engineer can estimate the nuclear valve fundamental frequency before committing resources to the final design and manufacturing processes.

SEALS

81-764

Nonlinear Dynamic Analysis of a Peripheral Seal on an HTGR Core Subjected to Seismic Support Motions

A. Chuang
General Atomic Co., San Diego, CA, ASME Paper No. 80-C2/PVP-21

Key Words: Seals (stoppers), Nuclear reactors, Seismic response

A theoretical study is made of the nonlinear response of a diamond-shaped cross section of an axisymmetric, peripheral seal excited by seismically induced multiple boundary motions. The influence of various system parameters on the response of the seal was also examined. The seal is located between the core and prestressed concrete reactor vessel (PCRV) of a high-temperature gas-cooled reactor (HTGR).

STRUCTURAL COMPONENTS

STRINGS AND ROPES

81-765

Frequency Analysis of Flat Cable Nets: A Simple Model

B. deV. Batchelor and M.L. Gambhir

Queen's Univ., Kingston, Ontario, Canada, ASCE J. Engr. Mech. Div., 106 (EM6), pp 1249-1264 (Dec 1980) 5 figs, 6 tables, 8 refs

Key Words: Cables (ropes), Natural frequencies

A simple numerical procedure is described for determining the natural frequencies of a system comprised of taut cables oscillating freely in the transverse direction. Application of the expressions to plane cable nets is presented to enable comparison with more involved formulations. It is shown how the predictions of these involved formulations can be obtained from the simple expressions derived in this paper.

Aeronautical Dev. Establishment, Indiranagar, Bangalore 560 038, India, Computers Struc., 12 (5), pp 721-728 (Nov 1980) 6 figs, 10 refs

Key Words: Beams, Timoshenko theories, Lumped parameter method, Mechanical impedance, Shock response

A lumped parameter model for Timoshenko beam clamped at both ends based on mechanical impedance is devised at low frequencies. Computations of the transient shear force and bending moment due to a low frequency ground acceleration show the usefulness of this method for shock analysis. The effect of correction due to shear deformation and rotary inertia on Timoshenko beam is discussed.

CABLES

81-766
Marine Cable Structures
A.H. Peyrot
Engrg. Dept., The Univ. of Wisconsin, Madison, WI, ASCE J. Struc. Div., 106 (ST12), pp 2391-2404 (Dec 1980) 11 figs, 1 table, 9 refs

Key Words: Cables (ropes), Off-shore structures, Dynamic structural analysis

An efficient method for the static and dynamic analysis of marine cable structures is presented. These structures may consist of floating platforms, buoys, weights, anchors, etc., interconnected by arbitrary arrangements of cables and flexible pipes. Displacements or forces can be specified at any number of nodal points and wave or current interaction can be simulated. The efficiency of the method has been demonstrated by several applications: dynamic response of a deepwater oil production platform, anchor drop, sonar towing, dynamic stiffness of mooring lines, tankers loading systems with flexible pipes, etc. Because the analysis technique is based on simple long curved cable elements, it outperforms all the currently available methods which use series of short straight links to model the cables.

BEAMS

81-767
Lumped Parameter Model for Timoshenko Beam Based on Mechanical Impedance
V.P. Rangaiah and V.H. Neubert

81-768
The Steady State Out-of-Plane Response of a Timoshenko Curved Beam with Internal Damping
T. Irie, G. Yamada, and I. Takahashi
Dept. of Mechanical Engineering, Hokkaido Univ., Sapporo 060, Japan, J. Sound Vib., 71 (1), pp 145-156 (July 8, 1980) 10 refs, 6 figs, 1 table

Key Words: Curved beams, Timoshenko theory, Internal damping, Periodic response

The steady state out-of-plane response of a Timoshenko curved beam with internal damping to a sinusoidally varying point force or moment is determined by use of the transfer matrix approach. For this purpose, the equations of out-of-plane vibration of a curved beam are written as a coupled set of the first order differential equations by using the transfer matrix of the beam. Once the matrix has been determined by numerical integration of the equations, the steady state response of the beam is obtained. The method is applied to free-clamped non-uniform beams with circular, elliptical, catenary and parabolical neutral axes driven at the free end; the driving point impedance and force or moment transmissibility are calculated numerically and the effects of the slenderness ratio, varying cross-section and the function expressing the neutral axis on them are studied.

81-769
On Prandtl's Cantilever Beam Subjected to a Bending Moment
Z. Celep
Faculty of Engrg. and Architecture, Technical Univ.,

Istanbul, Turkey, J. Sound Vib., 71 (2), pp 185-190 (July 22, 1980) 8 refs, 3 figs

Key Words: Cantilever beams, Flutter

The stability behavior of a cantilever beam subjected to the bending moment is investigated. It is found that the beam has divergence and flutter instability loads depending on the type of the loading. Moreover, it is shown that a beam subjected to a follower moment and a beam subjected to a bending moment which keeps its direction in the course of the motion behave in exactly the same way, according to the numerical calculations.

CYLINDERS

81-770

Effects of Structural Flexibility on Hydrodynamic Forces

Y. Chen

Ph.D. Thesis, Polytechnic Inst. of New York, 107 pp (1980)

UM 8019392

Key Words: Cylinders, Heaving, Hydrodynamic excitation, Fluid-induced excitation

An analytical procedure is developed for determining the hydrodynamic forces for cylinders heaving in the free surface of a fluid of infinite depth. The effects of structural flexibility are considered, and the solution of the hydroelastic coupled problem is obtained by appealing to the surface integral method (for the fluid) and the finite element method (for the structure). A computer program based on the approach is developed. The frequency dependence of added mass and damping coefficients is obtained, first, for rigid circular, elliptical, Lewis form and rectangular cross sections. Comparisons of the results to those obtained previously reveal very good agreement.

81-771

Theoretical-Experimental Seismic Tests of Fluid Coupled Co-Axial Cylinders

S.J. Brown, Jr.

O'Donnell & Associates, Inc., Pittsburgh, PA, ASME Paper No. 80-C2/PVP-45

Key Words: Cylinders, Cylindrical shells, Seismic response

In the design of fluid coupled flexible cylindrical structures subjected to seismic loading, many mechanism conditions can combine to present a complex problem. For such problems, the design analyst is usually concerned about the suitability of his theoretical model to account for fluid damping, convected velocities, phase relationships, mass formulation, boundary conditions, flexibilities, time history, response spectrum, code requirements, and analytical verification. This paper presents a series of comparisons between experimental seismic data and three-dimensional linear finite element analyses of the experimental tests.

COLUMNS

81-772

Column Response to Horizontal-Vertical Earthquakes

Y.K. Lin and T. Shih

Univ. of Illinois at Urbana-Champaign, Urbana, IL, ASCE J. Engr. Mech. Div., 106 (EM6), pp 1099-1109 (Dec 1980) 4 figs, 1 table, 32 refs

Key Words: Columns, Seismic response

Using a simple structural model which consists of a massless column supporting a concentrated mass at the top, it is shown that the vertical ground motion in an earthquake can amplify the power of the horizontal ground motion, and cause greater horizontal structural displacement response. Furthermore, this amplification effect is greater for greater initial response; i.e., the response initially computed without taking the vertical excitation into consideraion. Although the present analysis is based on a linear structural model numerical computations have included large deflections so that the general trend can become more visible, and the results so obtained can provide useful guides for future investigation into the nonlinear inelastic regimes.

81-773

Rocking Response of Rigid Blocks to Earthquakes

C. Yim, A.K. Chopra, and J. Penzien

Dept. of Civil Engrg., Univ. of California, Berkeley, CA, Intl. J. Earthquake Engr. Struc. Dynam., 8 (6), pp 565-587 (Nov/Dec 1980) 21 figs, 13 refs

Key Words: Columns, Seismic response, Ground motion, Computer programs

This investigation deals with the rocking response of rigid blocks subjected to earthquake ground motion. A numerical procedure and computer program are developed to solve the non-linear equations of motion governing the rocking motion of rigid blocks on a rigid base subjected to horizontal and vertical ground motion. The response results presented show that the response of the block is very sensitive to small changes in its size and slenderness ratio and to the details of ground motion. It is concluded that probabilistic estimates of the intensity of ground shaking may be obtained from its observed effects on monuments, minarets, tombstones and other similar objects provided suitable data in sufficient quantity is available, and the estimates are based on probabilistic analyses of the rocking response of rigid blocks, considering their non-linear dynamic behavior.

PANELS

81-774

Response of a Panel to a Supersonic Turbulent Boundary Layer: Studies on a Theoretical Model

D.H.Y. Yen, K. Maestrello, and S.L. Padula
Dept. of Mathematics, Michigan State Univ., East Lansing, MI 48824, J. Sound Vib., 71 (2), pp 271-282 (July 22, 1980) 2 figs, 13 refs

Key Words: Panels, Turbulence

The response of a clamped panel to a supersonic turbulent boundary layer is studied on the basis of a recently developed theoretical model. This model, in the form of an integro-differential equation, incorporates the effect of coupling between the panel motion and the flow of the surrounding fluid. A Ritz-Galerkin method is used to obtain approximate solutions for the statistics of the panel response to the turbulence. Comparisons of the numerical results with previous experimental data are presented and assessments of the theoretical model in the light of such comparisons are made.

PLATES

(Also see No. 855)

81-775

Response of an Elastically Supported Plate Strip to a Moving Load

H. Saito, S. Chonan, and O. Kawanobe
Dept. of Mech. Engrg., Tohoku Univ., Sendai, Japan, J. Sound Vib., 71 (2), pp 191-199 (July 22, 1980) 6 figs, 7 refs

Key Words: Plates, Elastic foundations, Moving loads

A theoretical analysis is presented of the steady state response of a plate strip constrained elastically along its edges against rotation and translation under the action of a moving transverse line load. Within the classical plate theory the solutions are obtained by using Fourier and Laplace transformation methods with respect to space variables. Numerical results are given for a plate strip with both edges identically constrained and a normal line load of constant intensity traveling along the plate strip with a constant speed. The first five speeds of the applied load for which a resonance effect occurs in the system are plotted as functions of the edge constraint parameters. The profiles of the displacement and the moment of the plate are also shown graphically for several values of the load speed and the edge constraint parameters.

81-776

Vibration of Thick Rectangular Plates of Bimodulus Composite Material

C.W. Bert, J.N. Reddy, W.C. Chao, and V.S. Reddy
School of Aerospace Mechanical and Nuclear Engrg., Oklahoma Univ., Norman, OK, Rept. No. OU-AMNE-80-8, TR-15, 30 pp (May 1980)
AD-A087 424/8

Key Words: Plates, Rectangular plates, Composite materials, Finite element technique

A finite-element analysis is carried out for small-amplitude free vibration of laminated, anisotropic, rectangular plates having arbitrary boundary conditions, finite thickness-shear moduli, rotatory inertia, and bimodulus action (different elastic properties depending upon whether the fiber-direction strain is tensile or compressive). The element has five degrees of freedom, three displacements and two slope functions, per node. An exact closed-form solution is also presented for the special case of freely supported single-layer orthotropic and two-layer, cross-ply plates. This provides benchmarks to evaluate the validity of the finite-element analysis. Both solutions are compared with numerical results existing in the literature for special cases (all for ordinary, not bimodulus, materials) and good agreement is obtained.

81-777

Vibration and Buckling Analysis of Plates of Abruptly Varying Stiffness

T. Mizusawa, T. Kajita, and M. Naruoka
Dept. of Construction Engrg., Daido Inst. of Tech., Hakusuicho-40, Minami-ku, Nagoya, 457, Japan, Computers Struc., 12 (5), pp 689-693 (Nov 1980) 4 figs, 5 tables, 13 refs

Key Words: Plates, Variable material properties, Variable cross section, Skew plates

The application of B-spline functions and the Rayleigh-Ritz procedure to analyze vibration and buckling of plates with abruptly varying stiffnesses is presented. Numerical examples of stepped thickness plates and perforated plates are presented and the results are discussed in comparison with those of other approximate methods. To demonstrate the versatility of the present method, vibration and buckling of skew plates of stepped thickness are also studied for various skew angles, ratios of thickness and ratios of width.

81-778

Random Vibration of an Initially Stressed Thick Plate on an Elastic Foundation

S. Chonan

Dept. of Mech. Engrg., Tohoku Univ., Sendai, Japan, J. Sound Vib., 71 (1), pp 117-127 (July 8, 1980) 5 figs, 11 refs

Key Words: Rectangular plates, Elastic foundations, Random vibration

The mean-square bending moment of a thick rectangular plate excited by a uniform distribution of stationary random forces that are uncorrelated in space is calculated. The plate has in-plane compressive or tensile stresses. In addition, the plate is mounted on an elastic foundation. Numerical results are given for plates with uniform initial stress when the temporal correlation function of the excitation possesses an exponential decay. The mean-square response amplitude of the plate on a foundation never exceeds that of the plate without a foundation, regardless of the intensity of the initial stress or the geometrical configuration of the plate.

81-779

Response of a Mindlin Plate with Trunnion

L.D. Pope

Bolt Beranek and Newman, Inc., Canoga Park, CA 91305, J. Sound Vib., 71 (1), pp 17-31 (July 8, 1980) 14 figs, 4 refs

Key Words: Circular plates, Harmonic excitation, Rotating structures, Transverse shear deformation effects, Rotatory inertia effects

The vibratory response of a circular plate with a central trunnion is considered. A harmonic force is allowed to act on the trunnion in a plane parallel to the surface of the plate. The model allows for arbitrary location of the center of mass of the trunnion and the line of action of the exciting force. The plate equations include the effects of transverse shear deformations and rotatory inertia, which makes the analysis useful for either thick or thin plates at acoustic frequencies. Application of the model in the control of noise and vibration of rotating machinery is illustrated.

81-780

A Study of the Parametric Stability of Skew Stiffened Plates Using Finite Elements

I.A. Allotey

Ph.D. Thesis, Univ. of Kansas, 468 pp (1979)
UM 8026722

Key Words: Skew plates, Stiffened plates, Parametric resonance, Finite element technique

Finite elements are used in this study to develop a theory capable of handling cases of skew plates, multispan plates, arbitrary stiffener orientation, eccentric stiffeners of symmetrical or unsymmetrical section, torsional or warping effects in the stiffeners, arbitrary axial or shear in-plane loading, other boundary conditions such as clamped, point or free supports in addition to simple supports, plates of variable rigidity, and orthotropic plates. For the finite element analysis, a new parallelogram plate element is created with arbitrarily oriented stiffeners. Element matrices are derived for this element through the use of expressions for the instantaneous total potential energy of the system and the principle of minimum potential energy. Equations of motion are set up from these element matrices from which the instability regions are derived. The behavior of the new element in linear analysis, static buckling, natural frequency and parametric resonance regions is examined by comparing the computed results with existing solutions. Finally, solutions of many examples with unknown solutions are presented in the results.

SHELLS

(Also see No. 855)

81-781

Excitation of Cylindrical Shell Vibrations as a Result of Pipe-Wall-Acoustic Coincidence from Internal Sound Fields

J.L. Walter, O.H. McDaniel, and G. Reethof

Pennsylvania State Univ., University Park, PA, ASME Paper No. 79-WA/DSC-25

Key Words: Cylindrical shells, Valves, Pipes (tubes), Acoustic excitation

The throttling process in control valves and regulators generates an intense sound field downstream from the valve's orificial element. This sound field excites plane waves as well as higher order acoustic modes in the cylindrical pipe. The interaction of these higher order acoustic modes with the pipe wall vibratory modes is shown to be strongest at the coincidence frequencies. At these frequencies the specific acoustic mode and its like pipe vibratory flexural mode have identical phase velocities. At coincidence there exists an efficient energy exchange which results in a large reduction in the pipe wall's transmission loss. The coincidence frequencies for the various modes occurs near but always above the duct cut-off frequencies. This paper describes a theoretical investigation and experimental verification of the coincidence phenomenon.

81-782

Earthquake Response of Deformable Liquid Storage Tanks

G.W. Housner and M.A. Haroun

California Inst. of Tech., Pasadena, CA, ASME Paper No. 80-C2/PVP-79

Key Words: Cylindrical shells, Storage tanks, Seismic response, Modal superposition method

A method for analyzing the earthquake response of deformable, cylindrical liquid storage tanks is presented. The method is based on superposition of the free lateral vibrational modes obtained by a finite element approach and a boundary solution technique.

81-783

Seismic Analysis of a Cylindrical Liquid Storage Tank with a Dome by the Finite Element Method

T. Balendra and W.A. Nash

Univ. of Singapore, ASME Paper No. 80-C2/PVP-74

Key Words: Cylindrical shells, Storage tanks, Fluid-filled containers, Seismic response, Finite element technique

The structure under consideration is an elastic cylindrical liquid storage tank with an elastic dome. The tank is attached to a rigid base slab. The liquid in the tank is assumed to be inviscid and incompressible. A finite element analysis is presented for the free vibrations of the coupled liquid-elastic system permitting determination of natural frequencies and associate mode shapes.

81-784

Scale Model Buckling Tests of a Fluid Filled Tank under Harmonic Excitation

C.-F. Shih and C.D. Babcock

California Inst. of Tech., Pasadena, CA, ASME Paper No. 80-C2/PVP-66

Key Words: Storage tanks, Fluid-filled containers, Dynamic buckling, Harmonic excitation

An experimental investigation of the buckling of fluid filled tanks under harmonic base excitation has been carried out. The adequacy of the scale modeling used in the experimental work is discussed.

PIPES AND TUBES

(Also see No. 781)

81-785

Static and Dynamic Properties of Pipe Whip Specimen Materials

D. Peterson, J.E. Schwabe, and D.G. Fertis

The Babcock & Wilcox Co., Alliance, OH, ASME Paper No. 80-C2/PVP-7

Key Words: Pipes (tubes), Nuclear power plants

It is a well established fact that many materials, including piping and restraint materials, exhibit an increase in yield strength when subjected to dynamic loads. This paper presents results of an experimental investigation to provide material properties of piping specimens planned for use during experimental testing that simulates postulated pipe whip in a nuclear power plant.

81-786

Prediction of Large Deformation Pipe Whip and Barrier Impact: A Simplified Approach

R.E. Roemer and G.H. East

Stone & Webster Engrg. Corp., Boston, MA, ASME Paper No. 80-C2/PVP-48

Key Words: Pipes (tubes)

Prediction of the large deformation behavior of ruptured pipes whipping into barriers has been limited to either end of the spectrum of analytical methods. At one end are the simplistic static energy balance techniques, valid only for the simplest of piping geometries. At the other are highly sophisticated finite element beam and shell techniques which are applied to virtually all other geometries. A simplified technique for predicting the dynamic behavior of whipping pipes in relatively complex geometries is presented.

81-787

Design and Fabrication Considerations for U Bar Type Pipe Whip Restraints

D.P. Munson, E. Willey, and D. Olson

Meddco Metals, Hayward, CA, ASME Paper No. 80-C2/PVP-53

Key Words: Design techniques, Pipes (tubes)

An upcoming nonmandatory appendix to the ASME Section III Code will contain generic design and fabrication guidance for pipe whip restraints. Irrespective of this guidance, there are a number of considerations for definition by the restraint designer which are the responsibility of the owner. Engineering considerations include selection of material properties for the restraint members, optimizing the number of rods and rod diameter in each restraint assembly, and definition of the restraint design load. Additional fabrication requirements include definition of member tolerances, method of upsetting the rod ends, requirements for bending and annealing of the rods, and selection of NDE acceptance standards. The significance of each of these provisions as they affect restraint fabrication is discussed.

81-788

Design Concepts for Pipe Whip Restraints

O. Gurbuz

Bechtel Power Corp., Norwalk, CA, ASME Paper No. 80-C2/PVP-56

Key Words: Nuclear power plants, Pipes (tubes)

This paper discusses the characteristics of several types of pipe whip restraints which have been either proposed or actually used in nuclear power plants.

81-789

Efficient Pipe Whip Restraint Design

A.J. Spada and N.A. Goldstein

Stone & Webster Engrg. Corp., Boston, MA, ASME Paper No. 80-C2/PVP-54

Key Words: Pipes (tubes), Design techniques, Energy absorption

The designs presented in this paper represent the culmination of a design development process. It addresses three basic designs: the laminated strap restraint (energy absorbing), the "pipe crush bumper" (energy absorbing), and the crush engineered limit stop (displacement limiting). Salient features of the designs are discussed, as well as some interesting problems associated with their development.

81-790

Dynamic Stability of Elastically Supported Pipes Conveying Pulsating Fluid

S.T. Noah and G.R. Hopkins

Dept. of Mech. Engrg., Texas A&M Univ., College Station, TX 77843, J. Sound Vib., 71 (1), pp 103-116 (July 8, 1980) 5 figs, 16 refs, 1 table

Key Words: Pipes (tubes), Fluid-filled containers, Elastic foundations

The effect of support flexibility on the dynamic behavior of pipes conveying fluid is investigated for both steady and pulsatile flows. The pipes are built-in at the upstream end and supported at the other by both a translational and a rotational spring. For the steady flow condition, the critical flow velocities, the frequencies and flow induced damping patterns that are associated with the different vibration modes of selected pipe systems are determined as functions of the flow velocity. The results from steady flow cases show that the pipes may first lose stability by either buckling or flutter, depending on the values of the rotational and translational spring constants and their relative magnitudes. In the case of pulsatile flow, the Floquet theory is utilized for the stability analysis of the selected pipe-fluid systems. Numerical results are presented to illustrate the effects of the amount of translational and rotational resiliences at the elastic support on the regions of parametric and combination resonances of the pipes.

81-791

Steady-State Vibration in Condensate Piping Due to Pump Operation

J.B. Mahoney, M. Ramchandani, and S.T. Hsu

Burns & Roe, South Paramus, NJ, ASME Paper No. 80-CS/PVP-46

Key Words: Electric power plants, Piping systems, Fatigue life, Supports, Fluid-induced excitation

Steady-state vibration in the condensate lines during the startup phases of a power plant have been recorded at a number of critical locations. These vibrations are caused by pump operations and fluid flow. A verification of these experimental results is provided by the simulation of the pressure oscillations on a hydraulic code. Using these forcing functions to excite the piping structure, time history analysis was performed to provide an optimum support system, which would minimize probable fatigue failure in the condensate lines.

81-792

Beam Versus Shell Seismic Analysis of Large Diameter Thin Wall LMFBR Piping

N. Pal

General Electric Co., Sunnyvale, CA, ASME Paper No. 80-C2/PVP-38

Key Words: Pipes (tubes), Seismic design

The adequacy of using beam theory in seismic design of large diameter, thin wall piping which is typically used in LMFBR, heat transport system (HTS) piping is examined. Representative test examples of HTS piping are selected and idealized in separate finite element models as three-dimensional beams and shells.

81-793

Earthquake Response of Buried Insulated Pipes

A. Hindy and M. Novak

Pipe Stress Group, Stone & Webster, Toronto, Ontario, Canada, ASCE J. Engr. Mech. Div., 106 (EM6), pp 1135-1149 (Dec 1980) 7 figs, 32 refs

Key Words: Pipes (tubes), Underground structures, Seismic response, Interaction: soil-structures

The effect of insulation on axial stresses induced in straight buried pipes due to earthquakes is investigated theoretically. Complex soil reactions are formulated for a viscoelastic medium composed of a softer inner ring and a stiffer outer layer. Seismic response of pipes is analyzed using both distributed and lumped mass models. The excitation is represented by traveling harmonic waves, fully-correlated transient waves, and partially-correlated random ground motion. It is found that insulation always reduces the stresses in straight pipes but this reduction is not as great as might be expected.

81-794

More on Flexibility Analysis of Buried Pipe

E.C. Goodling, Jr.

Gilbert Associates, Inc., Reading, PA, ASME Paper No. 80-C2/PVP-67

Key Words: Pipelines, Underground structures, Joints (junctions), Flexible couplings, Seismic design, Standards and codes

This paper updates procedures for establishing design values for seismic and soil characteristics and describes an improved method of performing flexibility analysis of buried steel elbows to reduce the degree of conservatism of the results. Included also is a discussion of those portions of Section III of the ASME Boiler and Pressure Vessel Code which are applied to buried piping. Design considerations involving flexible joints and couplings are discussed with suggestions for their use to accommodate certain design conditions. The paper is directed toward providing a maximum of usable information to the engineer engaged in design or analysis of actual nuclear or lifeline installations.

81-795

Parametric Seismic Responses of Buried Pipelines

L. RuLiang Wang

Rensselaer Polytechnic Inst., Troy, NY, ASME Paper No. 80-C2/PVP-71

Key Words: Pipelines, Underground structures, Seismic response, Earthquake damage

Pipeline damage caused by longitudinal earthquake excitations has been observed to be a major mode of failure. This paper describes a parametric quasi-static analysis model for the responses of long buried pipelines subjected to earthquake ground shaking in the axial direction. The effects of pipeline responses due to various physical, geological and seismological parameters were studied.

81-796

On Buckling of Buried Pipelines by Seismic Excitation

L.H.N. Lee, C.C. Chen, and T. Ariman

Univ. of Notre Dame, Notre Dame, IN, ASME Paper No. 80-C2/PVP-75

Key Words: Pipelines, Underground structures, Seismic excitation, Dynamic buckling

A quasi-bifurcation theory of dynamic buckling and a simple flow theory of plasticity are employed to analyze the axisymmetric, elastic-plastic buckling behavior of buried pipelines subject to seismic excitations.

81-797

Buried Pipeline Response to Permanent Earthquake Ground Movements

T.D. O'Rourke and G.H. Trautmann
Cornell Univ., Ithaca, NY, ASME Paper No. 80-C2/PVP-78

Key Words: Pipelines, Underground structures, Ground motion, Earthquakes

This paper examines the effects of large ground movements on buried pipelines. Ground displacement observations and records of pipeline damage are reviewed with special attention directed to fault movement effects. The long-term records of maintenance for buried utilities in areas of fault creep are examined. The vulnerability of pipelines to damage as a function of their construction is studied with emphasis on field records.

81-798

Ground Strain Estimation for Seismic Risk Analysis of Underground Lifelines

M. Shinozuka, T. Koike, and H. Kameda
Columbia Univ., New York, NY, ASME Paper No. 80-C2/PVP-69

Key Words: Lifeline systems, Pipelines, Underground structures, Seismic response

Assuming that the significant seismic deformations of pipeline structures embedded in a layered medium resting on a semi-infinite rock formation are primarily caused by surface waves, and in particular by the Rayleigh wave, a method is developed to derive the expressions for the Rayleigh wave that produces acceleration at the ground surface with a specified power spectral density and for the corresponding free-field normal ground strain at any depth in the medium.

81-799

New Methodologies for Analyzing Pipeline and Other Lifeline Networks Relative to Seismic Risk

R.F. Barlow, A.D. Kiureghian, and A. Satyanarayana
Univ. of California, Berkeley, CA, ASME Paper No. 80-C2/PVP-65

Key Words: Pipelines, Seismic response, Graphic methods

Lifeline systems (pipelines, distribution systems, etc.) are modeled as networks of interconnecting links and vertices. The existing methodology for computing the reliability of such networks is reviewed. New graph theory techniques for the analysis of large-size networks are presented. These are used in conjunction with improved seismic risk analysis techniques to evaluate network reliability against earthquakes.

81-800

Water System Network Analysis under Seismic Hazard

C. Hendrickson, D. Kufert, and I. Oppenheim
Carnegie-Mellon Univ., Pittsburgh, PA, ASME Paper No. 80-C2/PVP-62

Key Words: Pipelines, Seismic response

Water system malperformance is generally evidenced by a shortfall in deliveries to users. Calculation of the shortfall requires a network flow analysis; this analysis must be efficient if it is embedded with a seismic hazard simulation. An example network is analyzed using four related damage measures.

81-801

Pressure Transient Analysis of Elbow-Pipe Experiments Using the PTA-2 Computer Code

C.K. Youngdahl, C.A. Kot, and R.A. Valentin
Argonne National Lab., Argonne, IL, ASME Paper No. 80-C2/PVP-22

Key Words: Piping systems, Pulse excitation, Computer programs

Severe hydraulic transients may be produced in the intermediate heat transport system of a liquid-metal-cooled breeder reactor by a sodium/water reaction in a failed steam generator. The PTA-2 computer code has been developed to analyze these transients, including the effects of plastic deformation of the piping and cavitation on pulse propagation. Comparisons are shown between PTA-2 predictions.

81-802
Screening Procedures for Vibrational Qualification of Nuclear Plant Piping
J.E. Stoneking and R.C. Kryter
Univ. of Tennessee, Knoxville, TN, ASME Paper No. 80-C2/PVP-4

Key Words: Piping systems, Nuclear power plants, Vibration tolerance

In this paper vibratory stress levels are compared in three representative piping systems that are predicted by finite element analysis with those predicted by the proposed simplified screening procedures. Results indicate that in most instances the screening procedures are conservative for piping qualification purposes, i.e., they overpredict vibratory stress.

81-803
Transient Cavitation in Fluid-Structure Interactions
C.A. Kot, B.J. Hsieh, C.K. Youngdahl, and R.A. Valentin
Argonne National Lab., Argonne, IL, ASME Paper No. 80-C2/PVP-23

Key Words: Piping systems, Interaction: structure-fluid

A procedure has been developed to compute fluid-structure interactions as part of an overall analysis of fluid transients in piping system. The effects of cavitation on fluid-structure interactions are treated by an extension of a generalized column separation model. The calculation procedure is general and can be employed with a variety of structural response computations including multidimensional finite element codes.

81-804
Reliability of the California State Water Project
A.S. Kiremidjian
Stanford Univ., Stanford, CA, ASME Paper No. 80-C2/PVP-63

Key Words: Lifeline systems, Pumping, Tunnels, Waterworks, Seismic response

The objective of this paper is to obtain an estimate on the reliability of the California State Water Project when subjected to an earthquake. The water system is modeled as a network with reservoirs pumping plants and tunnels representing its nodes. Failure of nodes is taken to be due primarily to ground vibration and for the case of tunnels failure can be also due to differential displacements along a fault which crosses a tunnel.

BUILDING COMPONENTS

(Also see No. 834)

81-805
Nonstationary Random Response of Structural Systems to Aerodynamic Wind Forces
H. Singh
Ph.D. Thesis, Wayne State Univ., 114 pp (1980)
UM 8022791

Key Words: Structural response, Wind-induced excitation

Second-order statistics of system response to unsteady aerodynamic wind forces of limited time-duration are studied. Characteristics of severe climatic conditions are represented by modeling the wind velocity field as a time-modulated nonstationary process. Application of the nonstationary theory and minimization of system response over a constraint set of system design parameters are illustrated through a numerical example.

81-806
Seismic Response of Precast Concrete Walls
J.M. Becker, C. Llorente, and P. Mueller
Massachusetts Inst. of Tech., Cambridge, MA, Intl. J. Earthquake Engr. Struc. Dynam., 8 (6), pp 545-564 (Nov/Dec 1980) 20 figs, 1 table, 27 refs

Key Words: Walls, Precast concrete, Seismic response

This paper reports on research into the seismic behavior of simple precast concrete walls. The research was carried out through the development of computer-based modeling techniques capable of including the typical behavioral characteristics associated with horizontal joints. The model assumes that all non-linear, inelastic behavior is concentrated in the connection regions and that the precast panels remain linear elastic. A series of parametric studies are presented to illustrate the potential influence of rocking and slip on precast walls with both regular reinforcement and post-tensioning. The paper concludes with a brief discussion of the design implications of these results. Particular attention is paid to the problems stemming from the force concentrations associated with rocking and shear slip.

DYNAMIC ENVIRONMENT

ACOUSTIC EXCITATION

(Also see No. 853)

81-807

Highway Noise Barriers: New Shapes

D.N. May and M.M. Osman

Acoustics Office, Research and Development Division, Ministry of Transportation and Communications, Downsview, Ontario M3M, 1J8, Canada, J. Sound Vib., 71 (1), pp 73-101 (July 8, 1980) 20 figs, 7 tables, 49 refs

Key Words: Noise barriers, Traffic noise

This paper describes the relative acoustical performances established by scale model testing of a number of relatively novel noise barriers in typical highway situations. The various barriers were thin, wide, T-profiled, cylindrically topped, corrugated, inclined, Y-profiled, arrow-profiled and of the thnadner principle, and some were treated with sound absorptive material. The highway situations involved a single barrier with a protected receiver (i.e., a receiver behind the barrier), a single barrier with a receiver on the opposite side of the highway, and parallel barriers, one on each side of the highway.

81-808

The Performance of Sound Absorptive, Reflective, and T-Profile Noise Barriers in Toronto

D.N. May and M.M. Osman

Acoustics Office, Research and Development Division, Ministry of Transportation and Communications, Downsview, Ontario M3M 1J8, Canada, J. Sound Vib., 71 (1), pp 65-71 (July 8, 1980) 5 figs, 2 tables, 9 refs

Key Words: Noise barriers, Traffic noise

A 4m high highway noise barrier in Toronto was tested first with an absorptive side, second with a reflective side, and finally with a horizontal cap 75 cm wide mounted on its top to create a T-profile. Sound measurements in the residential community behind the barrier showed the T-profile barrier to produce a noise reduction 1 - 1·5 dB(A) greater than the same barrier without the cap. There was no statistically significant difference between the noise reductions produced by the absorptive and the reflective configurations.

81-809

Highway Noise Barrier Location for Maximum Benefit/Cost

C. Andrew, D.N. May, and M.M. Osman

Acoustics Office, Research and Development Division, Ministry of Transportation and Communications, Downsview, Ontario M3M 1J8, Canada, J. Sound Vib., 71 (1), pp 59-64 (July 8, 1980) 3 figs, 4 tables, 3 refs

Key Words: Noise barrier, Traffic noise

A benefit/cost analysis of noise barrier location was conducted, which suggests that for flat terrain, or terrain in which the roadway and receivers are equally elevated but separated by a ditch or other depression, the best barrier location is near the receiver; for roadways raised above the right-of-way by 4 ft or more, the best barrier location is probably near the highway, but this should be verified by detail design; for a depressed roadway, the best barrier location is near the receiver; and for terrain in which the roadway and receivers are separated by more elevated terrain, barrier location must be studied in detail – for elevations of the intermediate terrain that exceed the grade elevation by 2 ft or so, the best barrier location may be the raised intermediate point.

81-810

Durability of Sound Absorbing Materials for Highway Noise Barriers

A. Behar and D.N. May

Acoustics Office, Research and Development Division, Ministry of Transportation and Communications, Downsview, Ontario M3M 1J8, Canada, J. Sound Vib., 71 (1), pp 33-54 (July 8, 1980) 19 figs, 6 tables, 5 refs

Key Words: Noise barriers, Traffic noise, Acoustic absorption, Absorbers (materials)

This paper presents the results of a research study into two properties of sound absorbing materials intended for highway noise barrier applications: their durability and their sound absorption coefficients before and after exposure to adverse weather. After surveying the products of 34 manufacturers, eight materials and one "absorption system" were tested in the field and the laboratory. Even though there is no single, accepted test for weather endurance for these kinds of material, the results of the study provide information on their likely future behavior when installed on a barrier. The results apply at least partially to other outdoor situations too, and augment the limited information presently available on sound absorptive materials for outdoor use.

81-811

Vibration Damping Material as a Means to Reduce Steel Noise Barrier Cost

A. Behar and D.N. May

Acoustics Office, Research and Development Division, Ministry of Transportation and Communications, Downsview, Ontario M3M 1J8, Canada, J. Sound Vib., 71 (1), pp 55-58 (July 8, 1980) 3 figs, 1 table, 5 refs

Key Words: Noise barriers, Traffic noise, Vibration damping

A preliminary analysis has been made of the use of vibration damping material as a means to reduce the cost of steel noise barriers in primarily highway applications. For cost-effective barriers, the sound transmission through, as well as over, a noise barrier must be considered. The through-barrier sound transmission characteristics of sample panels from a Toronto noise barrier were measured with and without damping material. It was found that a given through-barrier sound transmission performance could be achieved at less cost with the damping material than without it.

81-812

Mitigation of Noise Impact via Operational Changes

R. Raspet

Army Construction Engrg. Res. Lab., Champaign, IL, Rept. No. CERL-TR-N-76, 23 pp (Sept 1979) N80-31156

Key Words: Ammunition, Artillery fire, Noise reduction, Noise generation, Computer-aided techniques

Three case studies which can serve as a guide for using operational changes of artillery and demolition to reduce noise impacts at Army installations are presented. In each case study, the initial and final noise impact is documented by computer generated equal noise contours. Operational changes may be used to reduce the total area impacted, to reduce the noise level in a particular location, or to shift the impacted area away from the noise sensitive areas.

81-813

Finite Element Analysis as a Diagnostic and Design Tool for Textile Spindle Noise Control

N.D. Stewart and J.R. Bailey

North Carolina State Univ., Raleigh, NC, ASME Paper No. 79-WA/DSC-4

Key Words: Textile spindles, Industrial facilities, Noise generation, Noise reduction, Finite element technique, SAP (computer program), Computer programs

Finite element analysis using available general-purpose structural analysis programs can be a valuable tool to noise control engineers in determining the natural frequencies and mode shapes of complex vibrating systems. The textile spindle is used as an example of noise problem requiring analysis. Use of the SAP IV program to model the system is discussed and results are compared with experimental data.

81-814

Rotary Lawn Mower Noise Measurement

D.A. Guenther

Ohio State Univ., Columbus, OH, ASME Paper No. 79-WA/Saf-3

Key Words: Lawn mowers, Noise measurement

In this paper, the sound level of low speed rotors is shown to vary as the fourth power of the tip velocity. The rotors examined had diameters from 16 in. to 26 in. and were operated at rotational mach numbers of 0.11 to 0.45. The two modes of sound generation specifically examined were the rotational component and the vortex component.

81-815

Reverberation Time Measurements in Industrial Noise Control

C.M. Steele

C.M. Steele & Assoc., N.S.W. Australia, ASME Paper No. 79-WA/Saf-2

Key Words: Industrial Facilities, Noise generation, Noise reduction, Noise measurement, Reverberation

The paper discusses some reverberation time measurements in four buildings and the application of these measurements to the determination of sound pressure levels.

81-816

Partial Enclosures – Effective Control of Punch Press Noise

J.W. Storment and H.K. Pelton

Western Electric Co., Shreveport, LA, S/V, Sound Vib., 14 (10), pp 10-13 (Oct 1980) 10 figs, 10 refs

Key Words: Presses, Noise reduction, Industrial facilities, Noise generation, Enclosures

This article outlines the application of partial enclosures to control punch press noise. The application is most effective on automatic punch presses.

81-817

Effect of Background Levels on Community Responses to Aircraft Noise

S.M. Taylor, F.L. Hall, and S.E. Birnie

Dept. of Geography, McMaster Univ., Hamilton, Ontario L8S 4K1, Canada, J. Sound Vib., 71 (2), pp 261-270 (July 22, 1980) 4 tables, 13 refs

Key Words: Aircraft noise, Human response

The effect of variations in background noise levels on community reactions to aircraft noise has been investigated by using questionnaire and sound level data collected at a stratified random sample of residential sites in the vicinity of Toronto International Airport. The effects of variations in background noise (24 hour L_{eq}) on both individual and aggregate responses to aircraft noise have been examined. The response variables considered include annoyance, activity interference and complaints. The results of various statistical analyses show that the effect of background level is generally not significant. These findings are consistent with relevant findings from previous laboratory studies, but not with those from previous field studies.

SHOCK EXCITATION

(Also see Nos. 736, 738, 757, 799, 800, 804, 853)

81-818

Impact Force Prediction Using Measured Frequency Response Functions

R.J. Thornhill

Ph.D. Thesis, Univ. of Texas at Austin, 186 pp (1980) UM 8021521

Key Words: Impact force, Frequency response, Fourier transformation

This dissertation presents an investigation of a method for impact force prediction using measured frequency response functions. The class of problems considered are those for which a mass, modeled as an ideal mass, experiences an elastic collision with a stationary structure. It is shown that a frequency response function measured at the point of collision on the structure together with the impactor's mass and velocity can be used to form a function which, after inverse Fourier transformation, is the impact force prediction. Both predicted and measured impact forces are presented for a steel missile impacting a simple supported beam and an aluminum casting. A comparison of predicted to measured impact forces indicate that if the physical nonlinear contact stiffness is modeled as an ideal spring very good predictions are possible in terms of pulse duration and time-to-peak-force. The limitations of the method due to hardware and experimental technique are also discussed.

81-819

Born Approximation for Wave Scattering in Elastodynamics

L.L. Chu, A.S. Cakmak, and A. Askar

Princeton Univ., Princeton, NJ, ASME Paper No. 80-C2/PVP-72

Key Words: Interaction: soil-structure, Wave diffraction

An approximate solution technique for the scattering problem in elastodynamics is developed. The approach, which would be useful in soil-structure interaction problems, is by means of formulating the scattering problem of incident waves in an integral equation form that admits an iterative solution; the problem is examined for incident SH waves scattered by both circular cavities.

81-820

A Study of the Effect of Stiffness Distribution on Nonlinear Seismic Response of Multi-Degree-of-Freedom Structures

D. Capecchi, G. Rega, and F. Vestroni

Comitato Nazionale per l'Energia Nucleare, Rome, Italy, Engrg. Struc., 2 (4), pp 244-252 (Oct 1980) 13 figs, 3 tables, 18 refs

Key Words: Multidegree of freedom systems, Seismic response, Earthquake response, Stiffness coefficients

The ductility requirement of elastoplastic multi-degree of freedom shear structures is studied by analyzing the response obtained through step-by-step integration of the equations of motion for some recorded accelerograms. In view of the high dependence of the structural strength reserve beyond the elastic range on the distribution of plastic deformations in the structure, this paper aims to establish the influence of the stiffness distribution and of the earthquake features on the local ductility demand. Attention is also paid to the analysis of the influence of variation in excitation intensity and duration on the seismic behavior of the structural models considered.

81-821

Structural Response to Stationary Excitation

A.D. Kiureghian
Univ. of California at Berkeley, Berkeley, CA, ASCE
J. Engr. Mech. Div., 106 (EM6), pp 1195-1213 (Dec 1980) 8 figs, 9 refs

Key Words: Dynamic response, Seismic excitation, Modal superposition method

Stationary responses of single- and multi-degree-of-freedom structures subjected to stationary input excitations are studied. Using a modal superposition procedure, closed-form solutions for the first three spectral moments of response to white-noise and filtered white-noise inputs are derived. These solutions are in terms of cross-modal contributions and explicitly account for the correlation between modal responses of multi-degree structures; thus, they are applicable to structures with closely spaced frequencies. Special attention is given excitations which are typical of earthquake ground motions. Various quantities of response can be obtained in terms of the three spectral moments. These include mean zero-crossing rate and mean, variance, and distribution of peak response over a specified duration. In this regard, improved, semi-empirical relations for the mean and variance of the peak of a stationary Gaussian process are developed. Results from study demonstrate range of applicability of white-noise model as an approximation for wide-band inputs.

81-822

Computation of Seismic Response from Higher Frequency Modes

K.M. Vashi
Westinghouse Electric Corp., Pittsburgh, PA, ASME
Paper No. 80-C2/PVP-50

Key Words: Seismic response, High frequency excitation, Modal superposition method, Response spectra

A general procedure is presented for a more accurate, rapid and economical computation of response from higher frequency modes, when the modal superposition time history or response spectra method is used for dynamic analysis of structures subject to uniform, translational seismic excitation. The procedure utilizes special amplification characteristics of earthquake loading for frequencies not less than a certain assigned value and certain properties of structural modal characteristics.

81-823

A Bayesian Geophysical Model for Seismic Hazard

M.W. McCann
Ph.D. Thesis, Stanford Univ., 339 pp (1980)
UM 8024709

Key Words: Earthquakes, Ground motion

Seismic hazard analysis is concerned with defining the expected future hazard due to earthquakes. This dissertation addresses the problem of modeling the ground shaking intensity given the occurrence of a seismic event. This work has two basic components: an empirical study of the root mean square acceleration and duration as a more realistic summary of earthquake ground motion shaking, and the development of a Bayesian probability model for deriving a probabilistic power spectral density function of ground motion.

81-824

Seismic Design of Equipment Supports and Connections in Industrial Installations -- A Brief Summary

U. Yuceoglu
Lehigh Univ., Bethlehem, PA, ASME
Paper No. 80-C2/PVP-73

Key Words: Equipment response, Equipment mounts, Seismic response, Standards and codes

This is the preliminary summary of a study program on the seismic dynamic response of the equipment and machinery systems including their supports and connections in industrial installations. The equipment and machinery encountered in industrial and non-nuclear facilities include a wide range in types of units. A brief review of the design criteria, methods of analysis, and the related codes and standards for the equipment systems are presented.

81-825
Seismic Response by SRSS for Nonproportional Damping

M.P. Singh
Virginia Polytech. Inst. & State Univ., Blacksburg, VA, ASCE J. Engr. Mech. Div., 106 (EM6), pp 1405-1419 (Dec 1980) 1 table, 25 refs

Key Words: Seismic response, Dynamic structural analysis, Damping effects

A method is presented to obtain seismic design response of linearly behaving structures with nonproportional damping characteristics. For such systems, time history analyses are usually performed to obtain accurate seismic response. Procedures have been developed to ascertain appropriate values of modal dampings so that modal analysis aproach and thus commonly adopted square-root-of-the-sum-of-the-squares (SRSS) procedures can be used. The approach presented here considers nonproportional damping effects exactly in analytical sense. It uses state-vector formulation and is based on random vibration principles. The approach is similar to conventional SRSS approach and thus ground response spectrum can be directly used to obtain designed response.

VIBRATION EXCITATION

81-826
Motion Characteristics of Floating Structures

A. Nishitani
Ph.D. Thesis, Columbia Univ., 85 pp (1980)
UM 8023531

Key Words: Floating structures, Damping effects, Time domain method

An engineering approach to the time domain analysis which accounts for the effects of damping is developed for the purpose of evaluating the rigid body response motion of a two-dimensional floating body confined in a fixed basin. The finite element analysis is employed in evaluating, in terms of the frequency dependent added mass coefficients, the hydrodynamic interaction forces between the floating body and the ideal fluid in the basin in which the body oscillates in both the heave and roll modes.

81-827
First-Passage Approximations for Simple Oscillators

L.D. Lutes, Y.T. Chen, and S. Tzuang
Dept. of Civ. Engrg., Rice Univ., Houston, TX, ASCE J. Engr. Mech. Div., 106 (EM6), pp 1111-1124 (Dec 1980) 3 figs, 16 refs

Key Words: Oscillators, Single degree of freedom systems, Random response

Simple analytical formulas are presented for approximate computation of the first-passage probabilities for the random response of a linear single-degree-of-freedom system. The response is taken to be zero-start and the excitation is stationary white noise with a normal probability distribution. Both small-time (nonstationary) and large-time (stationary) responses are included. Certain attractive existing approximate procedures are shown to be sometimes very significantly in error. The new formulas to compute the two parameters of the stationary problem are based on empirical data and the results of an existing approximate procedure which is quite accurate but cumbersome to use. Given the parameters of the stationary problem, a simple procedure is presented for accurately approximating the nonstationary behavior. The limitation on the approximate results is that they do not apply if the crossing level is smaller than the root mean square value of the stationary response.

81-828
Mean Square Response of a Duffing Oscillator to a Modulated White Noise Excitation by the Generalized Method of Equivalent Linearization

G. Ahmadi
Dept. of Mech. Engrg., Shiraz Univ., Shiraz, Iran, J. Sound Vib., 71 (1), pp 9-15 (July 8, 1980) 31 refs

Key Words: Non-linear systems, Random response, Equivalent linearization method

The non-stationary random response of non-linear systems is considered. The technique of equivalent linearization is generalized for application to non-stationary and non-linear random systems and several approximate methods of solution are presented. The example of a Duffing oscillator is studied in detail and its mean square response is evaluated and discussed.

81-829
Dynamic Response to Nonstationary Nonwhite Excitation

D.A. Gasparini and A. DebChaudhury
Case Western Reserve Univ., Cleveland, OH, ASCE J.

Engr. Mech. Div., 106 (EM6), pp 1233-1248 (Dec 1980) 13 figs, 1 table, 17 refs

Key Words: Multidegree of freedom systems, Random excitation

The root mean square responses of linear multidegrees-of-freedom system to nonstationary, nonwhite random excitation are computed analytically using the state space formulation. Each modal equation is augmented by a filter and the augmented system is driven by evolutionary white noise. Analytical expressions for the evolutionary covariance matrix of the augmented system are given. Modal RMS responses are then superposed to obtain the desired responses; all cross-correlation terms among modes are included. Nonstationary responses are computed for a four-degree-of-freedom system. The effects of nonstationary and nonwhiteness are quantified and examined. Responses are compared with those obtained by using an unfiltered formulation with different white noise intensities driving the modes.

MECHANICAL PROPERTIES

DAMPING

81-830

Structural Control Using Active Tuned Mass Dampers

J.C.H. Chang and T.T. Soong

Dept. of Civ. Engrg., State Univ. of New York at Buffalo, Buffalo, NY, ASCE J. Engr. Mech. Div., 106 (EM6), pp 1091-1098 (Dec 1980) 4 figs, 1 table, 5 refs

Key Words: Active damping, Tuned dampers, Buildings

Passive tuned dampers (TMD) are being used for motion control of tall buildings. The possibility of enhancing TMD effectiveness in structural with added active control capability is studied in this paper. The problem of structural control using active TMD is formulated using classical feedback control theory. Using simple numerical examples, it is shown that an addition of active control forces to TMD systems can lead to significant improvement in displacement and acceleration reductions. Furthermore, TMD stroke requirement can also be significantly reduced with added active control element.

81-831

Elastomer Damper Performance -- A Comparison with a Squeeze Film for a Supercritical Power Transmission Shaft

E.S. Zorzi, G. Burgess, and R. Cunningham

Mechanical Technology Inc., Latham, NY, ASME Paper No. 80-GT-162

Key Words: Elastomeric dampers, Shafts (machine elements), Power transmission systems

This paper describes the design and testing of an elastomer damper on a supercritical power transmission shaft. The elastomers were designed to provide acceptable operation through the fourth bending mode and to control synchronous as well as nonsynchronous vibration throughout the operating range.

81-832

Axisymmetrical Auxiliary Mass Nutation-Damper

I. Porat

Faculty of Mech. Engrg., Technion -- Israel Inst. of Tech., Haifa, Israel, Israel J. Tech., 17 (4), pp 201-206 (1979) 7 figs, 4 refs

Key Words: Nutation dampers, Gyroscopes

The possibility to suppress the vibrations of a free gyro by an auxiliary mass, attached to the rotor by an axisymmetrical mount which consists of spring and damper, is investigated. The mass and flexible mount rotate with the rotor. The mass has two-degree-of-freedom, relative translational displacements. In the first part an approximate model is considered assuming the gyro motion to be a forced moving base for the mass. In the second part the general case and the conditions for stability are considered. As a result the rotor has to be flat and the mass has to be subcritical.

81-833

A Study to Determine the Effect of Glass Compositional Variations on Vibration Damping Properties

G.A. Graves, Jr., C. Cannon, and S. Kumar

Univ. of Dayton Res. Inst., 300 College Park Ave., Dayton, OH 45469, Rept. No. AFWAL-TR-80-4061, pp 1-161 (May 1980) 77 figs, 30 tables, 23 refs

Key Words: Material damping, Glass

This report describes the results of an experimental investigation to determine the effects certain oxide additions have on the damping properties of a commercial glass (enamel) of known composition (Corning 0010) whose damping properties had previously been characterized. One of the aims of this investigation was to determine the effect the oxide additions had on the temperature at which peak damping occurred, singly and in combination.

FATIGUE

(Also see No. 856)

81-834

The Effect of Overloads on Fatigue Crack Propagation in Structural Components

K.M. Lai and I. LeMay
Univ. of Saskatchewan, Canada, ASME Paper No. 80-C2/PVP-9

Key Words: Structural members, Fatigue life

This paper presents a fatigue crack retardation model considering the crack closure effects arising from residual stresses in the vicinity of the crack tip. The model uses the effective stress range factor, U, for the constant amplitude cyclic loading and the effective stress range factor, U_0, for the first cycle followed by the overload cycle.

81-835

The Effect of Various Environments on the Fatigue Cracking of High Strength Aluminum Alloys

R.N. Miller and R.L. Smith
Lockheed-Georgia Co., Marietta, GA, ASME Paper No. 80-C2/PVP-11

Key Words: Fatigue tests, Fatigue (materials), Aluminum

Fatigue tests were conducted to determine the effect of various environments and operating conditions on the rate of crack propagation in aluminum aircraft alloys. Center-cracked alum'num specimens were used. Precracking and testing were performed on electrohydraulic servocontrolled testing machines.

81-836

Hybrid-Finite-Element Analysis of Some Nonlinear and 3-Dimensional Problems of Engineering Fracture Mechanics

S.N. Atluri, M. Nakagaki, and K. Kathiresan
Center for the Advancement of Computational Mechanics, School of Civil Engrg., Georgia Inst. of Tech., Atlanta, GA 30332, Computers Struc., 12 (4), pp 511-520 (Oct 1980) 11 figs, 22 refs

Key Words: Fatigue life, Crack propagation

In this paper, efficient numerical methods for the analysis of crack-closure effects on fatigue-crack-growth-rates, in plane stress situations, and for the solution of stress-intensity factors for arbitrary shaped surface flaws in pressure vessels, are presented. For the former problem, an elastic-plastic finite element procedure valid for the case of finite deformation gradients is developed and crack growth is simulated by the translation of near-crack-tip elements with embedded plastic singularities. For the latter problem, an embedded-elastic-singularity hybrid finite element method, which leads to a direct evaluation of K-factors, is employed.

EXPERIMENTATION

DYNAMIC TESTS

(Also see No. 757)

81-837

Dynamic Measurements of Micropolar Elastic Constants

W.E. Jahsman and R.D. Gauthier
Dept. of Engrg. Sciences, Oxford Univ., UK, Rept. No. OUEL-1291/91, 47 pp (1979)
N80-30819

Key Words: Measurement techniques, Impact tests, Elastic properties, Composite materials

A series of dynamic tests utilizing a compression type Kolsky apparatus was conducted. Short cylindrical specimens machined from bulk composite material were subjected to short duration compressive pulses. Similar tests were conducted on specimens of the constituent materials of the composite. Differences are observed between the records for the constituent materials and for the composite specimen. The records for the constituents are smooth and compared well with predictions based on one dimensional wave propagation through homogeneous isotropic elastic solids. On the basis of these results, it is concluded that for certain composites dynamic measurements can provide the resolution needed to determine at least some of the micropolar elastic constants.

81-838
Dynamic Covariance Equations for Hinged Wavemakers
R.T. Hudspeth and J.W. Leonard
Dept. of Civil Engrg. and Ocean Engrg. Programs, Oregon State Univ., Corvallis, OR 97331, Engrg. Struc., 2 (4), pp 217-224 (Oct 1980) 8 figs, 2 tables, 10 refs

Key Words: Test facilities, Water waves

The squared modulus of the theoretical dimensionless frequency response functions for the wavemaker stroke spectrum and for the wavemaker hydrodynamic pressure moment spectrum were verified experimentally for hinged wavemakers of variable-draft in the Oregon State Wave Research Facility. The random motions of the hinged wavemaker that were employed in the experimental studies were synthesized on a mini-computer from two types of two-parameter theoretical design wave spectra by a unique inverse stacked finite Fourier transform algorithm.

MONITORING

81-839
How Close Are Your Feed Pumps to Instability-Caused Disaster?
E. Makay
Energy Res. & Consultants Corp., Power, 124 (12), pp 69-71 (Dec 1980) 6 figs

Key Words: Pumps, Monitoring techniques

The effects of poor specifications, incomplete and ill-interpreted instrumentation, and basic lack of understanding of such factors as oil whip, impeller clearance, and even hydrostatic effects on the life and overall performance of vital machinery are discussed.

ANALYSIS AND DESIGN

ANALYTICAL METHODS

81-840
Multibody Structural Dynamics Including Translation Between the Bodies
R.L. Huston and C.E. Passerello
Univ. of Cincinnati, Cincinnati, OH 45221, Computers Struc., 12 (5), pp 713-720 (Nov 1980) 4 figs, 2 tables, 60 refs

Key Words: Translational response, Mechanical systems

New and recently developed concepts used for obtaining and solving equations of motion of multibody mechanical systems with translation between the respective bodies of the system, is presented. The incorporation of translation effects make the analysis applicable to a much broader class of problems than was possible with previous analyses which are restricted to linked multibody systems. The concepts developed in the analysis include the use of Euler parameters, Lagrange's form of d'Alembert's principle, quasi-coordinates, relative coordinates, and body connection arrays. Procedures for the development of efficient computer algorithms for evaluating the coefficients of the governing equations of motion are outlined. The methods presented are directly applicable in the analysis of biodynamic and human models, finite segment cable models, mechanisms, manipulators and robots.

81-841
Bond Graphs for Distributed Systems Models Admitting Mixed Causal Inputs
D.L. Margolis
Univ. of California, Davis, CA, ASME Paper No. 79-WA/DSC-24

Key Words: Bond graph technique, Continuous parameter method

Bond graphs are used for finite mode representations of distributed system dynamics. As long as all inputs to the system are "efforts" in a causal sense, then no formulation problems exist. However, if some of the system inputs are causal "flows," then differential casuality will exist and extremely tedious, often impossible, algebraic loops must be solved to formulate system equations. A procedure is developed which avoids these algebraic problems by including additional modal compliance in the system model without its associated modal inertia.

81-842
Performance of Reduction Methods for Fluid-Structure and Acoustic Eigenvalue Problems
W.J.T. Daniel
Dept. of Mech. Engrg., Univ. of Queensland, Bris-

bane, Australia, Intl. J. Numer. Methods Engr., 15 (11), pp 1585-1594 (Nov 1980) 2 figs, 5 tables, 9 refs

Key Words: Interaction: structure-fluid, Eigenvalue problems, Reduction methods, Acoustic response

A methodology is presented for measuring the effectiveness of a finite element approach when compared with a reference finite element approach with respect to accuracy and computation. The effectiveness measure is applied to the Hughes reduction method for structural eigenvalue problems and three proposed analogous methods for fluid or fluid-structure problems. Comparisons of the three methods with consistent interpolation solutions indicate that improved effectiveness can be obtained.

81-843

Nonlinear Dynamic Analysis of a Structure Subjected to Multiple Support Motions

V.M. Shah and A.J. Hartmann

Westinghouse Electric Corp., Pittsburgh, PA, ASME Paper No. 80-C2/PVP-52

Key Words: Modal superposition method, Dynamic structural analysis, Supports, Finite element technique

A modal superposition method for the nonlinear dynamic analysis of a structure subjected to multiple support motions is presented. The nonlinearities are due to clearances between the components and their supports. The finite element method is used to derive the equations of motion with the nonlinearities represented by a pseudo force vector.

81-844

Lyapunov Characteristic Exponents for Smooth Dynamical Systems and for Hamiltonian Systems; A Method for Computing All of Them. Part 1: Theory

G. Benettin, L. Galgani, A. Giorgilli, and J. Strelcyn

Istituto di Fisica dell'Universita, Via Marzola 8, 35100 Padova, Meccanica, 15 (1), pp 9-20 (Mar 1980) 28 refs

Key Words: Stochastic processes, Lyapunov's method

Lyapunov characteristic exponents are of interest for the study of dynamical systems to characterize quantitatively their stochasticity properties. The problem of the explicit computation of such exponents exists. A method for computing all of them, based on the computation of the exponents of order greater than one, which are related to the increase of volumes is given. To this end a theorem is given relating the exponents of order one to those of greater order.

81-845

Lyapunov Characteristic Exponents for Smooth Dynamical Systems and for Hamiltonian Systems; A Method for Computing All of Them. Part 2: Numerical Application

G. Benettin, L. Galgani, A. Giorgilli, and J. Strelcyn

Istituto di Fisica dell'Universita, Via Marzola 8, 35100 Padova, Meccanica, 15 (1), pp 21-30 (Mar 1980) 6 figs, 23 refs

Key Words: Stochastic processes, Lyapunov's method

This paper is intended to give an explicit method for computing all Lyapunov characteristic exponents of a dynamical system. In this paper the computational method is described and some numerical examples for mappings on manifolds and for Hamiltonian systems are given.

81-846

Mathematical Models and Optimization Problems for a Class of Multibodied Homokinetic Systems Rotating About a Fixed Point

N. Bellomo and R. Monaco

Istituto di Meccanica Razionale, Politecnico di Torino, Italy, Meccanica, 15 (1), pp 3-8 (Mar 1980) 6 figs, 8 refs

Key Words: Rotating structures, Mathematical models, Optimization

This work proposes a theory for study of the torque transmission with friction in a large class of multibodied systems with fixed point for the homokinetic transmission of the motion between two converging axes. The results point out the influence of the geometrical parameters characterizing the system upon the behavior of functions, here proposed, which describe the torque transmission with friction. Numerical calculations, optimization problems, and mathematical models visualize the results of the afore-mentioned theory.

MODELING TECHNIQUES

(See No. 860)

NUMERICAL METHODS

81-847

The Gelfand-Levitan, the Marchenko, and the Gopinath-Sondhi Integral Equations of Inverse Scattering Theory, Regarded in the Context of Inverse Impulse-Response Problems

R. Burridge
Courant Inst. of Mathematical Sciences, New York Univ., New York, NY 10012, Wave Motion, 2 (4), pp 305-323 (Oct 1980) 16 figs, 19 refs

Key Words: Integral equations, Impact response (mechanical), Elastic waves, Seismic response, Time domain method

This paper is concerned with interpreting some classical inverse-scattering theories so that they are relevant to the one-dimensional inverse impulse-response problem which arises in reflection seismology. First the Gelfand-Levitan integral equations (which arise in the inverse scattering theory for the Schrödinger equation) are derived strictly in the time domain. Originally these equations were derived as a means of solving an inverse spectral problem, which is naturally posed in the frequency domain. The present paper opens with a section in which the equation of one-dimensional elastic waves and the corresponding seismic inverse impulse-response problem are transformed into a form to which the Gelfand-Levitan theory applies, and then into the equations which arose in Gopinath and Sondhi's work.

81-848

Reflection and Transmission of Elastic Waves by the Spatially Periodic Interface Between Two Solids (Theory of the Integral-Equation Method)

J.T. Fokkema
Dept. of Electrical Engrg., Lab of Electromagnetic Res., Delft Univ. of Tech., 2600 GA Delft, The Netherlands, Wave Motion, 2 (4), pp 375-393 (Oct 1980) 7 figs, 2 tables, 23 refs

Key Words: Integral equations, Elastic waves, Wave reflection, Wave transmission, Interface: solid-solid

The linear theory of two-dimensional reflection and transmission of time-harmonic, elastic waves by the spatially periodic interface between two perfectly elastic media is developed. A given phase progression of the incident wave in the direction of periodicity induces a modal structure in the elastodynamic field and leads to the introduction of the so-called spectral orders. The main tools in the analysis are the elastodynamic Green-type integral relations. They follow from the two-dimensional form of the elastodynamic field reciprocity theorem, where in the latter a Green state adjusted to the periodicity of the structure at hand is used. One of these relations is a vectorial integral equation from which the elastodynamic field quantities can be determined.

PARAMETER IDENTIFICATION

(Also see No. 859)

81-849

Practical Aspects of System Identification

T.L. Trankle
Systems Control Inc., Palo Alto, CA, ASME Paper No. 79-WA/DSC-23

Key Words: System identification techniques

System identification is a technology for determining a mathematical model of a dynamic system from observations of its response to inputs. The effective application of system identification requires the integration of test planning (choice of sensors and of input test signals), monitoring of test execution, and data processing. The proper choice of a data processing method is strongly dependent on the error characteristics of the measurements made on the system and on the system's environmental disturbances. Other considerations in choosing and implementing a data processing scheme include numerical consideration, choosing the model structure and the number of independent parameters to be estimated, validation of the estimated model, and the safe extrapolation of results.

81-850

Identifiability and Experimental Design Issues in Linear System Identification

J.G. Reid
Air-Force Inst. of Tech., Wright-Patterson AFB, OH, ASME Paper No. 79-WA/DSC-17

Key Words: System identification techniques, Parameter identification technique, Quasilinearization technique, Least squares method

This paper demonstrates how singular value decomposition may be used to address fundamental questions of identifiability and experimental design in the parameter identification of linear state space models. Assuming some form of a quasi-linearization algorithm is employed for identification, it is shown how readily available eigenvalue/eigenvector routines may be used to find the necessary sensitivity coefficient matrix in the resulting linear least squares problem.

81-851

System Identification by Dynamic Data System and Its Application to Kamyr Continuous Digester Pulping Process

Y. Liao

Ph.D. Thesis, University of Wisconsin, Madison, WI, 281 pp (1980)

UM 8025213

Key Words: System identification techniques, Dynamic data system technique

The use of a new modeling approach – Dynamic Data System (DDS) for system identification is investigated. Simulation evaluation was made between the DDS approach and the prevailing frequency domain approach in five different cases: the second, third and fourth order systems, and a system with closely spaced natural frequencies excited by white noise, and the second order systems excited by colored noise.

81-852

Progressing from Least Squares to Bayesian Estimation

J. Isenberg

J.H. Wiggins Co., Redondo Beach, CA, ASME Paper No. 79-WA/DSC-16

Key Words: Least squares method

This presentation concisely reviews and unifies the class of least-squares estimators – simple least-squares, weighted least-squares, nonlinear least-squares, minimum variance and Bayesian estimation. The advantages and limitations of each method are discussed. The approach is based on formulating and then minimizing an objective function for each method.

COMPUTER PROGRAMS

(Also see No. 722, 736, 801, 813)

81-853

The Blast Noise Prediction Program: User Reference Manual

V. Pawlowska and L. Little

Army Construction Engrg. Res. Lab., Champaign, IL, Rept. No. CERL-IR-N-75, 78 pp (Aug 1979)

N80-31155

Key Words: Computer programs, Blast excitation, Noise prediction

User instructions for the Blast Noise Prediction computer program, BNOISE 1.0, which is designed to predict the noise impacts of Army blast noise operations are provided. A sample run and a list of module error messages are provided, along with a description of the manipulation of the modules used by the Blast Noise program.

81-854

Analysis of Dynamic Systems Using Heuristic Optimization

N.A. Langrana and T.W. Lee

Rutgers Univ., New Brunswick, NJ, ASME Paper No. 79-WA/DSC-14

Key Words: Computer programs, Optimization, Design techniques

A general-purpose algorithm, the Heuristic Combinatorial Optimization Technique, has been demonstrated to produce fast and improved solutions in the kinematic and dynamic design of mechanical systems compared to conventional techniques. In the present study, a new approach is introduced. An effective algorithm is developed that combines the Heuristic Optimization Technique with the Automated Assembly Program to provide a systematic procedure to solve the inverse dynamic problem. Two problems are investigated. The first problem deals with a man-machine interaction system, and the second deals with the spatial motion of a manipulator. The investigation demonstrates the potential application of the procedure in the analysis of dynamic systems of realistic complexity.

81-855

Redesign of Structural Vibration Modes by Finite-Element Inverse Perturbation

K.A. Stetson and I.R. Harrison

United Technologies Res. Ctr., East Hartford, CT, ASME Paper No. 80-GT-167

Key Words: Computer programs, Shells, Cantilever plates, Cylinders, Compressor blades, Finite element technique

A previously developed technique for redesigning the vibrational properties of structures, by inverting the first-order perturbation analysis of the equations of motion, has been applied to a NASTRAN finite element analysis for plates and shells. The program finds the minimal changes to the thicknesses of the plate elements necessary to effect a given set of changes in the modal frequencies and shapes. Results have been obtained for a flat cantilever plate, a cantilever segment of a cylinder, and for a compressor blade for a jet engine.

81-856

Development of an Interactive Computer Program for Fatigue Analysis

Y.W. Luk and L.D. Mitchell

Virginia Polytechnic Inst. and State Univ., Blacksburg, VA, ASME Paper No. 79-DE-E-4

Key Words: Computer programs, Fatigue life, Mechanical elements

This paper presents the theory of and describes an interactive computer program for fatigue analysis. This program sizes mechanical components – circular, rectangular or other shapes – to prevent fatigue failure. The six most generally accepted fatigue failure lines are available, such as modified Goodman line, Gerber line, quadratic line, etc. Any equivalent stress theory, such as maximum distortion energy theory, is allowed. All types of load lines, both straight and curved, are accommodated.

81-857

The Shaft Book: Design Charts for Torsional Properties of Noncircular Shafts: User's Manual

R.I. Isakower

Scientific and Engrg. Applications Div., Army Armament Res. and Dev. Command, Dover, NJ, Rept. No. AD-A086498; MISD-UM-80-5, 95 pp (Mar 1980) N80-30752

Key Words: Computer programs, Shafts (machine elements), Torsional response

Design charts and tables havu been developed for the elastic torsional stress analyses of free prismatic shafts, splines and spring bars with virtually all commonly encountered cross sections. Circular shafts with rectangular and circular keyways, external splines, and milled flats along with rectangular and X-shaped torsion bars are presented. A computer program was developed which provides a finite difference solution to the governing (POISSON's) partial differential equation which defines the stress functions for solid and hollow shafts with generalized contours. The design data have been normalized for a unit dimension of the cross section (radius or length) and are provided in this report for solid shapes. The eleven solid shapes presented, along with the classical circular cross section solution, provides the means for analyzing 144 combinations of hollow shafts with various outer and inner contours. Hollow shafts may be analyzed by using the computer program directly or by using the solid shape charts in this report and the principles of superposition based on the concept of parallel shafts.

81-858

Ritz 2 Software: Dynamic Longitudinal Analysis Using a Variational Method for Slender Bodies of Revolution Containing Liquids (Logiciel Ritz 2 - Analyse Dynamique Longitudinale Par Methode Variationnelle de Structures Minces de Revolution Contenant des Liquides)

H. Morand and B. Belon

Centre National d'Etudes Spatiales, Toulouse, France, Rept. No. CNES-NT-91, 355 pp (Sept 1979) N80-30361 (In French)

Key Words: Computer programs, Launch vehicles, Liquid propellant rocket engines

A variational method to study launch vehicle structures by longitudinal modal analysis is presented along with the corresponding software. The method is especially well adapted to liquid propellant rocket behavior. The added mass of the liquid is calculated on the basis of a hydroelastic hypothesis and according to theoretically defined variation principles. A matrix representation is generated numerically using a finite element routine. Machine memory loading is minimized by a simultaneous assembly reduction subroutine. The RITZ 2 software computes eigenvalues, eigenvectors, generalized masses, and dynamic pressures for most axisymmetric configurations. The results are shown appropriate for pogo studies. A program user manual is also included.

GENERAL TOPICS

TUTORIALS AND REVIEWS

81-859
System Identification Techniques: A Tutorial Review
V.K. Jain and G.J. Dobeck
Univ. of South Florida, Tampa, FL, ASME Paper No. 79-WA/DSC-20

Key Words: System identification techniques, Least squares method, Quasilinearization technique, Optimization

A tutorial review of system identification techniques is presented. It is assumed that the structure of the model is known from the mechanics and physics of the plant, and that the test problem consists of identifying the unknown parameters of the model from observed dynamic responses. Both single-input, single-output plants and multi-input, multi-output plants are considered. The techniques described in detail are least squares, generalized least squares, quasi-linearization (or, modified Newton-Raphson), and maximum likelihood techniques. For completeness, a summary of optimization techniques is also included.

81-860
The Finite Element Method After Twenty-Five Years: A Personal View
R.W. Clough
Univ. of California, Berkeley, CA 94720, Computers Struc., 12 (4), pp 361-370 (Oct 1980) 4 figs, 46 refs

Key Words: Finite element technique, Reviews, Earthquake response

The purpose of this paper is to examine the current state of development of the finite element method with regard to engineering applications. First is presented a personal view of the origins of the method, describing the sequence of events at Berkeley. Next is a discussion of the state-of-the-art of structural dynamic analysis, with mention of important recent advances. Finally, two examples drawn from earthquake engineering experience are discussed which demonstrate some limitations of present capabilities. Specific areas requiring new program development are mentioned; the need for a combined analytical-experimental approach is emphasized.

81-861
Occupational Vibration Studies in the U.S. – A Review
D.E. Wasserman
National Inst. for Occupational Safety and Health, Cincinnati, OH, S/V, Sound Vib., 14 (10), pp 21-24 (Oct 1980) 22 refs

Key Words: Reviews, Vibration tolerance, Human response, Human hand

Occupational vibration studies conducted in the U.S. since 1971 are reviewed. It is estimated that some 8 million workers in the U.S. are exposed to occupational vibration, warranting epidemiology studies of truck and bus drivers, heavy equipment operators, and correlative field studies of vibration exposure as well as simulated environmental studies performed in the laboratory. Hand-arm vibration studies include an extensive field study of chipper/grinder workers, stonecutters, and miners.

81-862
Fluid-Structure Interaction
T. Belytschko
Dept. of Civil Engrg., Technological Inst., Northwestern Univ., Evanston, IL 60201, Computers Struc., 12 (4), pp 459-469 (Oct 1980) 10 figs, 23 refs

Key Words: Interaction: fluid-structure, Nuclear reactor components, Weapons effects, Finite element technique, Finite difference technique, Computer programs

Computational methods for fluid-structure analysis are surveyed. Emphasis is placed on semi-discretization methods, such as finite element and finite difference methods. Appropriate mesh descriptions and time integration procedures for various classes of problems are discussed. The need for mesh partitions, where the fluid and structure are integrated by different methods, is indicated, and three types of mesh partitions are discussed: explicit-implicit, implicit-implicit, and explicit with different time steps. Some examples are presented to illustrate the applicability of various methods.

81-863
Wave-Induced Ship Hull Vibrations: A Review
J.J. Jensen
Dept. of Ocean Engrg., Technical Univ. of Denmark, Dk-2800 Lyngby, Shock Vib. Dig., 12 (11), pp 19-25 (Nov 1980) 65 refs

Key Words: Reviews, Ship vibration, Ship hulls, Water waves

This article reviews methods for measuring wave-induced ship hull vibrations. The theoretical methods available for predicting whipping and springing vibrations are also reviewed.

81-864

Nonlinear Rotor Dynamics Analysis

M.L. Adams

Dept. of Mech. Engrg., Univ. of Akron, Akron, OH 44325, Shock Vib. Dig., 12 (11), pp 13-18 (Nov 1980) 4 figs, 16 refs

Key Words: Reviews, Rotors (machine elements), Nonlinear theories, Computerized simulation

This paper presents a state-of-the-art review of an increasingly important subject: nonlinear rotor dynamics. Recent advances in this field have led to new computer simulation techniques that have been shown to be accurate and computationally efficient. These techniques simulate transient and steady-state system responses of complex multi-bearing flexible rotor machines that involve highly nonlinear effects. This new computational capability should be of great value in answering the increasing number of failure-mode analysis questions.

81-865

Vibrations of Turbine Engine Blades by Shell Analysis

A.W. Leissa

Ohio State Univ., Columbus, OH 43210, Shock Vib. Dig., 12 (11), pp 3-10 (Nov 1980) 1 fig, 51 refs

Key Words: Reviews, Blades, Turbine engines, Shells, Vibration analysis

A great deal of research has gone into the analysis of free vibrations of rotating turbine engine blades. Most of the work has been done with the blades modeled as beams, however, and is inaccurate for higher frequency modes and for thin, short blades. This paper discusses considerations pertinent to accurate analyses of blade vibrations when the blades are modeled as shells, as well as the accomplishments to date.

CRITERIA, STANDARDS, AND SPECIFICATIONS

(Also see Nos. 737, 794, 824)

81-866

Criteria and Alternatives in the Selection of Noise Abatement Strategies

M.C. Junger

Cambridge Acoustical Associates Inc., Cambridge, MA, ASME Paper No. 79-WA/DSC-6

Key Words: Noise reduction, Regulations

The impact of economic and demographic pressures on noise legislation and abatement strategies is examined with the purpose of anticipating the evolution of noise control trends. After examining various facets of the relation between socio-economic factors and various noise problems, motor vehicle noise is selected as an example for detailed analysis.

AUTHOR INDEX

TECHNICAL NOTES

P.H. Denke and G.R. Eide
Matrix Difference Equation Analysis of Vibrating Circumferentially Periodic Structures
J. Spacecraft Rockets, 18 (1), pp 95-96 (Jan/Feb 1981) 4 figs, 1 table, 2 refs

A. Ikuta, S. Yamaguchi, and M. Ohta
A Statistical Consideration of Non-Stationary Random Noise and Vibration in View of Temporal Change of Cumulants and Its Application to Dynamical Prediction of L_x
J. Sound Vib., 72 (2), pp 267-272 (Sept 22, 1980) 2 figs, 5 refs

R.E. Mickens
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J. Sound Vib., 72 (2), pp 279-281 (Sept 22, 1980) 3 refs

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J. Sound Vib., 72 (2), pp 273-278 (Sept 22, 1980) 9 refs

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Free Vibration of an Annular Membrane with Mass Distributed at the Inner Edge
J. Sound Vib., 72 (1), pp 135-137 (Sept 8, 1980) 3 figs

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J. Sound Vib., 71 (3), pp 453-457 (Aug 8, 1980) 4 figs, 1 ref

G. Subramanian and T.V. Mathew
On a Method of Collocation by Derivatives
J. Sound Vib., 71 (3), pp 458-461 (Aug 8, 1980) 2 tables, 2 refs

C. Massalas and A. Leontitsis
Influence of the Panel Parameters on Its Dynamic Characteristics
Israel J. Tech., 17 (3), pp 175-178 (1979) 4 figs, 1 table, 5 refs

Z. Celep
Shear and Rotatory Inertia Effects on the Large Amplitude Vibration of the Initially Imperfect Plates
J. Appl. Mech., Trans. ASME, 47 (3), pp 662-666 (Sept 1980) 2 figs, 18 refs

M. Sathyamoorthy
Large Amplitude Vibration of Skew Orthotropic Plates
J. Appl. Mech., Trans. ASME, 47 (3), pp 675-677 (Sept 1980) 3 tables, 4 refs

T. Irie, G. Yamada, and S. Aomura
Natural Frequencies of Mindlin Circular Plates
J. Appl. Mech., Trans. ASME, 47 (3), pp 652-655 (Sept 1980) 3 tables, 4 refs

M. Dravinski
Wave Propagation in a Plate with Periodic Structure: Antiplane Strain Model
J. Appl. Mec!.., Trans. ASME, 47 (3), pp 660-662 (Sept 1980) 2 figs, 6 refs

H. Jaworowski, St. Kasprzyk, and J. Wapiennik
Vibroisolation Parameter Selection Method and Stability Determination of a Discrete-Continuous System of the (∞, 1) Type
Z. angew. Math. Mech., 60 (4), pp 212-214 (Apr 1980) 3 figs, 5 refs

P.A.A. Laura and R.H. Gutierrez
Comments on "Vibration Analysis of a Rectangular Plate Subjected to a Thermal Gradient"
J. Sound Vib., 72 (2), pp 263-264 (Sept 22, 1980) 2 refs

S.N. Yousri Gerges
The Variance of Sound Power Radiated by Higher Order Sources in a Reverberation Chamber
J. Sound Vib., 72 (1), pp 119-122 (Sept 8, 1980) 4 figs, 4 refs

CALENDAR

APRIL 1981

6-8 22nd Structures, Structural Dynamics, and Materials Conference [AIAA, ASME, ASCE, AHS] Atlanta, Georgia *(AIAA, ASME, ASCE, AHS Hqs.)*

6-9 NOISEXPO '81 [S/V, Sound and Vibration] Hyatt Regency O'Hare, Chicago, IL *(NOISEXPO '81, 27101 E. Oviatt Rd., Bay Village, OH 44140)*

27-30 27th Intl. Instrumentation Symposium [Aerospace Industries and Test Measurement Divisions of the Instrument Society of America] Hyatt Regency, Indianapolis, IN *(Jim Dorsey, c/o Measurements Group, P.O. Box 27777, Raleigh, NC 27611)*

MAY 1981

4-7 Institute of Environmental Sciences' 27th Annual Technical Meeting [IES] Los Angeles, CA *(IES, 940 East Northwest Highway, Mt. Prospect, IL 60056)*

31 - June 5 Spring Meeting and Exhibition of the Society for Experimental Stress Analysis [SESA] Hyatt Regency, Dearborn, MI *(SESA, P.O. Box 277, Saugatuck Station, Westport, CT 06880)*

JUNE 1981

1-4 Design Engineering Conference and Show [ASME] Chicago, IL *(ASME Hq.)*

8-10 NOISE-CON 81 [Institute of Noise Control Engineering and the School of Engineering, North Carolina State University] Raleigh, North Carolina *(Dr. Larry Royster, Program Chairman, Center for Acoustical Studies, Dept. of Mechanical & Aerospace Engr., North Carolina State University, Raleigh, NC 27650)*

22-24 Applied Mechanics Conference [ASME] Boulder, CO *(ASME Hq.)*

SEPTEMBER 1981

1-4 Joint Meeting of the British Society for Strain Measurement and the Society for Experimental Stress Analysis [B.S.S.M. and SESA] Edinburgh University, Scotland *(C. McCalvey, Administration Officer, B.S.S.M., 281 Heaton Road, Newcastle upon Tyne, NE6, 5OB, UK)*

7-11 Applied Modelling and Simulation Conference and Exhibition [I.A.S.T.E.D. and A.M.S.E.] Lyon, France *(A.M.S.E., 16, Avenue de Grande Blanche, 69160 Tassin-La-Demi-Lune, France)*

20-23 Design Engineering Technical Conference [ASME] Hartford, CT *(ASME Hq.)*

28-30 Specialists Meeting on "Dynamic Environmental Qualification Techniques" [AGARD Structures and Materials Panel] Noordwijkerhout, The Netherlands *(Dr. James J. Olsen, Structures and Dynamics Division, Air Force Wright Aeronautical Laboratories/FIB, Wright Patterson Air Force Base, OH 45433)*

30-Oct 2 International Congress on Recent Developments in Acoustic Intensity Measurement [CETIM] Senlis, France *(Dr. M. Bockhoff, Centre Technique des Industries Mecaniques, Boite Postale 67, F-60304, Senlis, France)*

OCTOBER 1981

4-7 International Lubrication Conference [ASME - ASLE] New Orleans, LA *(ASME Hq.)*

11-15 Fall Meeting of the Society for Experimental Stress Analysis [SESA] Keystone Resort, Keystone, CO *(SESA, P.O. Box 277, Saugatuck Station, Westport, CT 06880)*

19-22 Intl. Optimum Structural Design Symp. [U.S. Office of Naval Research and Univ. of Arizona] Tucson, AZ *(Dr. Erdal Atrek, Dept. of Civil Engr., Bldg. No. 72, Univ. of Arizona, Tucson AZ 85721)*

21-23 34th Mechanical Failures Prevention Group Symp. [National Bureau of Standards] Gaithersburg, MD *(J.E. Stern, Trident Engineering Associates, 1507 Amherst, Rd., Hyattsville, MD 20783 - (301) 422-9506)*

27-29 52nd Shock and Vibration Symposium [Shock and Vibration Information Center, Washington, D.C.] New Orleans, Louisiana *(Henry C. Pusey, Director, SVIC, Naval Research Lab., Code 5804, Washington, D.C. 20375)*

Eastern Design Engineering Show [ASME] New York, NY *(ASME Hq.)*

CALENDAR ACRONYM DEFINITIONS AND ADDRESSES OF SOCIETY HEADQUARTERS

AFIPS: American Federation of Information Processing Societies
210 Summit Ave., Montvale, NJ 07645

AGMA: American Gear Manufacturers Association
1330 Mass Ave., N.W.
Washington, D.C.

AHS: American Helicopter Society
1325 18 St. N.W.
Washington, D.C. 20036

AIAA: American Institute of Aeronautics and Astronautics, 1290 Sixth Ave.
New York, NY 10019

AIChE: American Institute of Chemical Engineers
345 E. 47th St.
New York, NY 10017

AREA: American Railway Engineering Association
59 E. Van Buren St.
Chicago, IL 60605

ARPA: Advanced Research Projects Agency

ASA: Acoustical Society of America
335 E. 45th St.
New York, NY 10017

ASCE: American Society of Civil Engineers
345 E. 45th St.
New York, NY 10017

ASME: American Society of Mechanical Engineers
345 E. 45th St.
New York, NY 10017

ASNT: American Society for Nondestructive Testing
914 Chicago Ave.
Evanston, IL 60202

ASQC: American Society for Quality Control
161 W. Wisconsin Ave.
Milwaukee, WI 53203

ASTM: American Society for Testing and Materials
1916 Race St.
Philadelphia, PA 19103

CCCAM: Chairman, c/o Dept. ME, Univ. Toronto,
Toronto 5, Ontario, Canada

ICF: International Congress on Fracture
Tohoku Univ.
Sendai, Japan

IEEE: Institute of Electrical and Electronics Engineers
345 E. 47th St.
New York, NY 10017

IES: Institute of Environmental Sciences
940 E. Northwest Highway
Mt. Prospect, IL 60056

IFToMM: International Federation for Theory of Machines and Mechanisms
U.S. Council for TMM
c/o Univ. Mass., Dept. ME
Amherst, MA 01002

INCE: Institute of Noise Control Engineering
P.O. Box 3206, Arlington Branch
Poughkeepsie, NY 12603

ISA: Instrument Society of America
400 Stanwix St.
Pittsburgh, PA 15222

ONR: Office of Naval Research
Code 40084, Dept. Navy
Arlington, VA 22217

SAE: Society of Automotive Engineers
400 Commonwealth Drive
Warrendale, PA 15096

SEE: Society of Environmental Engineers
6 Conduit St.
London W1R 9TG, UK

SESA: Society for Experimental Stress Analysis
21 Bridge Sq.
Westport, CT 06880

SNAME: Society of Naval Architects and Marine Engineers
74 Trinity Pl.
New York, NY 10006

SPE: Society of Petroleum Engineers
6200 N. Central Expressway
Dallas, TX 75206

SVIC: Shock and Vibration Information Center
Naval Research Lab., Code 5804
Washington, D.C. 20375

URSI-USNC: International Union of Radio Science - U.S. National Committee
c/o MIT Lincoln Lab.
Lexington, MA 02173

PUBLICATION POLICY

Unsolicited articles are accepted for publication in the Shock and Vibration Digest. Feature articles should be tutorials and/or reviews of areas of interest to shock and vibration engineers. Literature review articles should provide a subjective critique/summary of papers, patents, proceedings, and reports of a pertinent topic in the shock and vibration field. A literature review should stress important recent technology. Only pertinent literature should be cited. Illustrations are encouraged. Detailed mathematical derivations are discouraged; rather, simple formulas representing results should be used. When complex formulas cannot be avoided, a funtional form should be used so that readers will understand the interaction between parameters and variables.

Manuscripts must be typed (double-spaced) and figures attached. It is strongly recommended that line figures be rendered in ink or heavy pencil and neatly labeled. Photographs must be unscreened glossy black and white prints. The format for references shown in DIGEST articles is to be followed.

Manuscripts must begin with a brief abstract, or summary. Only material referred to in the text should be included in the list of References at the end of the article. References should be cited in text by consecutive numbers in brackets, as in the example below.

> **Unfortunately, such information is often unreliable, particularly statistical data pertinent to a reliability assessment, as has been previously noted [1].**
>
> **Critical and certain related excitations were first applied to the problem of assessing system reliability almost a decade ago [2]. Since then, the variations that have been developed and the practical applications that have been explored [3-7] indicate that . . .**

The format and style for the list of References at the end of the article are as follows:

- **each citation number as it appears in text (not in alphabetical order)**
- **last name of author/editor followed by initials or first name**
- **titles of articles within quotations, titles of books underlined**
- **abbreviated title of journal in which article was published (see Periodicals Scanned list in June and December issues)**
- **volume, number or issue, and pages for journals; publisher for books**
- **year of publication in parentheses**

A sample reference list is given below.

1. **Platzer, M.F., "Transonic Blade Flutter - A Survey," Shock Vib. Dig., 7, pp 97-106 (July 1975).**
2. **Bisplinghoff, R.L., Ashley, H., and Halfman, R.L., Aeroelasticity, Addison-Wesley (1955).**
3. **Jones, W.P., (Ed.), "Manual on Aeroelasticity," Part II, Aerodynamic Aspects, Advisory Group Aeronaut. Res. Devel. (1962).**
4. **Lin, C.C., Reissner, E., and Tsien, H., "On Two-Dimensional Nonsteady Motion of a Slender Body in a Compressible Fluid," J. Math. Phys., 27 (3), pp 220-231 (1948).**
5. **Landahl, M., Unsteady Transonic Flow, Pergamon Press (1961).**
6. **Miles, J.W., "The Compressible Flow Past an Oscillating Airfoil in a Wind Tunnel," J. Aeronaut. Sci., 23 (7), pp 671-678 (1956).**
7. **Lane, F., "Supersonic Flow Past an Oscillating Cascade with Supersonic Leading Edge Locus," J. Aeronaut. Sci., 24 (1), pp 65-66 (1957).**

Articles for the DIGEST will be reviewed for technical content and edited for style and format. Before an article is submitted, the topic area should be cleared with the editors of the DIGEST. Literature review topics are assigned on a first come basis. Topics should be narrow and well-defined. Articles should be 1500 to 2500 words in length. For additional information on topics and editorial policies, please contact:

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